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Field Project

A Critical Analysis of the Viability and Impacts of Solar Energy Carve-Outs in Renewable Portfolio Standards

By

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LIST OF ABBREVIATIONS AND ACRONYMS

AC	Alternating Current
BPU	Board of Public Utilities
Btu	British thermal unit
CdTe	Cadmium Telluride
CH_4	Methane
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CSP	Concentrating Solar Power
DC	Direct Current
DG	Distributed Generation
DNI	Direct Normal Irradiance
DOE	Department of Energy
DSIRE	Database of State Incentives for Renewable Energy
EIA	Energy Information Administration
EMGT	Engineering Management
EPA	Environmental Protection Agency
EPIA	European Photovoltaic Industry Association
FIT	Feed-In Tariff
GCF	Gross Capacity Factor
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GW	Gigawatt
GWh	Gigawatt-hour
Hg	Mercury
IOU	Investor-Owned Utility
ITC	Investment Tax Credit
J	Joule
KCP&L	Kansas City Power & Light
kW	kilowatt
kWh	kilowatt-hour
LBNL	Lawrence Berkeley National Laboratory
LCA	Life-Cycle Analysis

MACRS	Modified Accelerated Cost Recovery System
MMBtu	Million British thermal units
MMT	Million Tons
MW	Megawatt
MWh	Megawatt-hour
NAAQS	National Ambient Air Quality Standards
NO_x	Nitrogen Oxides
NREL	National Renewable Energy Laboratory
O_3	Ozone
Pb	Lead
$PM_{2.5}$	Particulate Matter of 2.5 Microns in Diameter or Smaller
PM_{10}	Particulate Matter of 10 Microns in Diameter or Smaller
POU	Publically-Owned Utility
PSC	Public Service Commission
PTC	Production Tax Credit
PV	Photovoltaic
REC	Renewable Energy Credit
RPS	Renewable Portfolio Standard
SACP	Solar Alternative Compliance Payment
SEIA	Solar Energy Information Administration
SO_x	Sulfur Oxide
SREC	Solar Renewable Energy Credit
TMY	Typical Meteorological Year
TW	Terawatt
TWh	Terawatt-hour
W	Watt

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Executive Summary

Numerous states have implemented legislation to advance the use of specific renewable energy resources, most notably solar. However, solar energy is accompanied by several deficiencies – including high costs, limited geographic applicability, and poor efficiency – which make its endorsement perilous. Despite its shortcomings, solar power resources are among the most popular forms of energy in the United States and an increasing number of states are adding provisions to their renewable portfolio standards to support them.

This report includes three detailed investigations to address the viability and impacts associated with solar carve-outs in renewable portfolio standards. In the first investigation, statistical methods are used to characterize and understand those states that have promoted carve-out legislation. In the second investigation, a nationwide differential analysis is performed to assess the economic impacts of large-scale solar energy utilization. Finally, the third investigation provides case studies of several states that have implemented solar energy carve-outs in order to empirically evaluate the economic and environmental impacts of solar carve-out policies.

The results of this study clearly highlight the deficiencies of solar carve-outs. These mandates will lead to billions of dollars in direct costs to ratepayers, increased electric rates, and the release of millions of additional tons of carbon dioxide into the atmosphere. Moreover, although more solar energy may ultimately be produced as a result of this legislation, it is not clear that any tangible benefits are derived from it. Thus, rather than specifying a winning technology, state legislators would be better served to instead outline the goals of their renewable energy policy, provide incentives to reach them, and leave the means of realizing the goals to the market.

Chapter 1 - Introduction

Energy is a fundamental part of life. It provides heat and light, it is used by billions of people to improve their daily standard of living, and it is expected at the flick of a switch. Energy is the lifeblood of modern economies, powering a nearly six-trillion dollar global business that accounts for more than 10 percent of the world's gross domestic product (Economist 2008). This resource is vitally important to the economic, technological, and social advancement and well-being of people throughout the world.

In the United States, energy is consumed faster than nearly any other country in the world. In fact, Americans consume nearly 25 percent of the world's electricity (EIA-a 2009). Moreover, per capita energy usage in the United States more than tripled between 1960 and 2007 (The World Bank 2010). This gluttonous pattern of consumption and an amplified focus on climate change has brought renewed attention to the way in which electricity is created.

Throughout the world, renewable energy resources are playing an increased role in the electric sector. These resources offer many advantages relative to more conventional forms of electrical generation such as coal. Most notably, renewable resources do not emit greenhouse gases (GHG), the dangerous emissions that have been linked by many to global climate change and have plagued the reputation of coal and other fossil fuel-fired resources. However, renewable resources are also accompanied by numerous impediments, such as high capital and energy costs and intermittent output.

To make renewable energy more cost-competitive and to accelerate its deployment in the United States, many states have turned to legislation. The resounding obstacle is that not all states are equally endowed with the same natural resources used to create renewable energy. Moreover, many states have adopted an artificial distinction that some renewable resources are better than others. The most prominent example of this trend is solar energy. Numerous states have implemented requirements for solar energy to comprise a minimum percentage of their electricity through mandates such as carve-outs and multipliers.

However, few (if any) of these states have performed detailed analyses to ascertain the viability or impacts of these mandates.

1.1 Study Objectives and Methodology

The principal component of this report is a comprehensive and critical review of solar energy carve-outs in renewable portfolio standards. This report begins with a discussion of renewable energy markets and what states are currently doing in terms of energy legislation. Thereafter, several detailed analyses are presented in which the viability and impacts of solar carve-outs in renewable portfolio standards are examined.

The purpose of this report is in no way intended as a diatribe on the use of renewable energy. Moreover, the causes and impacts of climate change will not be explored or commented on further. Rather, this report is used only to provide a thorough evaluation of solar energy carve-outs in renewable portfolio standards in order to understand the economic, environmental, and logistical issues that may result from their implementation.

1.2 Organization of Report

This report is organized into several separate chapters and supporting appendices. These individual chapters are listed below along with a brief description of their contents.

- **Chapter 1 - Introduction:** A detailed description of the report's necessity, objectives, and methodology.
- **Chapter 2 - Literature Review:** A discussion on the extent of current knowledge on the subject of solar carve-outs.
- **Chapter 3 - Overview of Study Investigations:** A brief introduction to the investigations and analyses to be completed in subsequent chapters.

- **Chapter 4 - Characterization of Carve-Out States:** A description of the first investigation completed as part of this study, a characterization of carve-out states.
- **Chapter 5 - National Differential Economic Analysis:** A description of the second investigation completed as part of this study, a national differential analysis of solar energy and more traditional, cost-competitive renewable resources.
- **Chapter 6 - State Case Studies:** A description of the third investigation completed as part of this study, a collection of case studies of three states that have implemented solar energy carve-outs in their renewable portfolio standards.
- **Chapter 7 - Conclusions:** The conclusions reached as part of the investigations and analyses completed for this report.
- **Chapter 8 - Suggestions for Additional Work:** During the course of this study, numerous areas of additional study beyond the scope of this report were identified and are presented in this chapter for those interested in opportunities for further investigation.

Throughout this report, references are made to a number of important terms. To aid the reader and to ensure a proper and clear understanding of these terms, a glossary has been included as Appendix A. Additionally, applicable conversion factors and equivalencies utilized for calculations in this report are summarized in Appendix B. Finally, a list of abbreviations and acronyms is found on page viii at the beginning of this report.

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Chapter 2 - Literature Review

A literature review was conducted to understand the extent of current knowledge on the subject of renewable energy and, more specifically, solar carve-outs. Through this review, numerous books and articles on the subject were examined, including those both for and against solar carve-outs. The objective of this chapter is to convey the knowledge and ideas that have been established on the topic, as well as to discuss the relative strengths and weaknesses of these concepts. The following sections present an overview of current research identified as part of this study.

2.1 Renewable Energy Overview

Before summarizing research on solar carve-outs in renewable portfolio standards, it is important to first understand the role of renewable resources in the current energy landscape. Renewables – such as wind, solar, hydroelectric, geothermal, and biomass – presently account for approximately 10.5 percent of net energy generation in the United States (EIA-b 2010). As seen in Figure 1, coal-fired generation is the largest contributor at nearly 45 percent of the U.S. total while nuclear and natural gas-fired sources cumulatively provide an additional 43.5 percent.

Of the 413 terawatt-hours (TWh) of renewable generation in the United States in 2009, nearly two-thirds was produced from hydroelectric power sources. Another 17 percent was produced by wind power while only 0.8 TWh, or 0.2 percent, was generated by solar power. A breakout of generation from renewable energy resources in 2009 is shown in Figure 2.

Despite the relatively limited role of renewables in the current electric sector, an increased focus on renewable energy is expected to continue market growth for these resources. By 2035, non-hydroelectric renewable energy generation is expected to reach approximately 589 TWh, a nearly 417 percent increase over 2009 levels (EIA-c 2010). However, solar resources are not expected to play a prominent role in the United States' energy market, with only 2.8 percent of renewable energy generation being derived from solar power by 2035. At that rate, solar power will represent only 1.3 percent of total electric capacity in the United States in 2035. Although this corresponds to a significant increase over 2009 levels, the role of solar energy in the country's long-term generation portfolio is extremely limited.

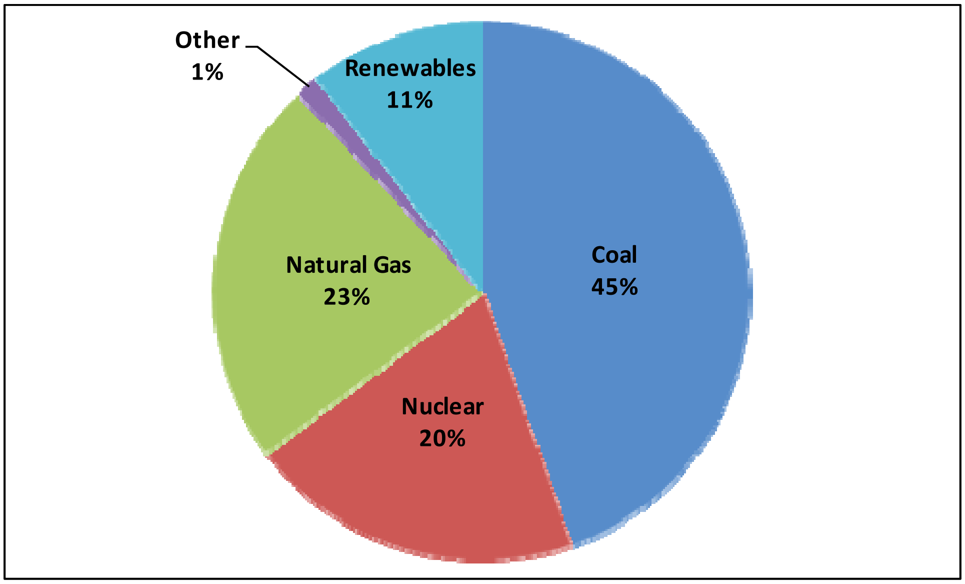

Figure 1. Net Generation by Energy Source (2009)

Source: (EIA-b 2010)

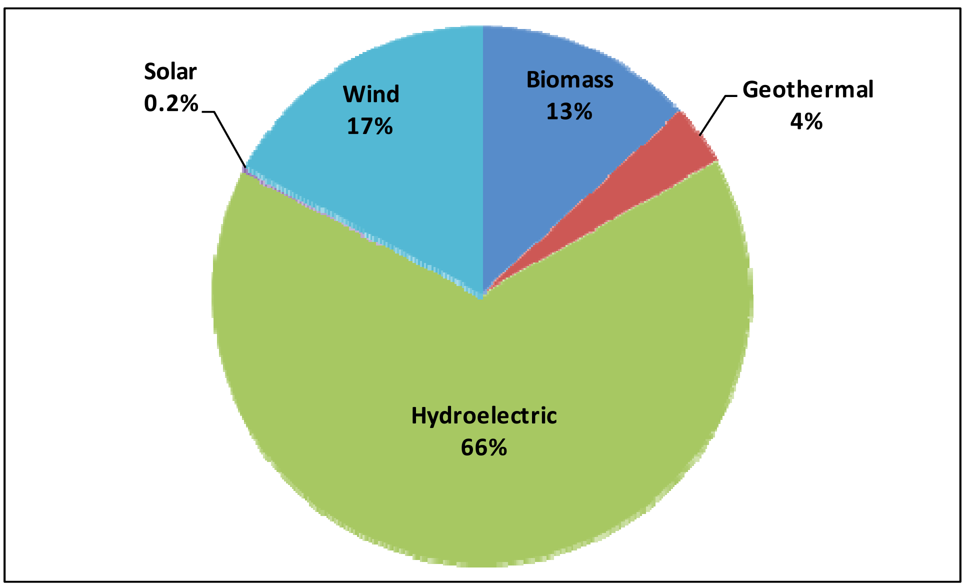

Figure 2. Net Renewable Generation by Energy Source (2009)

Source: (EIA-b 2010)

2.2 Solar Energy Overview

Despite their low level of current integration, solar power resources are incredibly popular in the United States. In recent industry surveys, 92 percent of Americans thought it important for the United States to develop and use solar energy (SEIA 2009). Similarly, 44 percent would make solar their top energy source, followed by wind at 17 percent. Many Americans are even willing to pay a premium for electricity that is derived from solar resources, with 49 percent willing to pay five additional dollars or more on their monthly electric bills if their utility company increased its use of renewable energy sources like solar (Applied Materials 2010).

The popularity of solar power is not startling. The sun is a part of daily life, making solar energy an extremely visible energy alternative. In fact, the amount of solar energy that reaches the United States each year is equivalent to an impressive 4,000 times the nation's electric power needs (Apt, Lave and Pattanariyankool 2008). Nevertheless, the visibility of the resource does not necessarily equate to its viability. Efficiency limitations with current solar technologies limit the amount of energy that can be captured and converted to electricity. Moreover, the most attractive solar resources are concentrated in the southwestern United States (see solar insolation maps in Appendix C for reference). Thus, despite the average American's perception that 18 percent of U.S. energy is sourced from solar power – nearly 9,000 times the actual amount of energy delivered from solar resources – opportunities for utilizing the sun's free energy are not as straightforward as many Americans tend to believe (Applied Materials 2010).

The sun offers a free and infinite source of fuel; however, harnessing its energy and turning it into customer-accessible electricity is not. Despite installed costs for solar photovoltaic (PV) falling an average of 3.6 percent per year for the past decade, energy from solar-powered resources is still among the most expensive forms of electricity currently available (Greentech Media 2009). Solar PV generally has a nonsubsidized, levelized cost of between $330 and $610 per megawatt-hour (MWh), nearly 10 times the cost of the country's current electric generation mix, and between three and five times the cost of other low-carbon generation (Apt, Lave and Pattanariyankool 2008).

The Energy Information Administration (EIA), a statistical agency of the United States, recently estimated average national levelized costs for various generation resources entering service in 2016. Levelized costs represent the present value of the total cost of building and operating a generating plant over its financial life, converted to equal annual payments and amortized over expected annual generation from an assumed duty cycle. According to the EIA's report, average national levelized costs for solar thermal and solar PV are approximately \$257/MWh and \$396/MWh, respectively, ranking as the most expensive sources of energy considered in their study (EIA-c 2010). In fact, the third most expensive technology – offshore wind power – had an average national cost of \$191/MWh, or nearly half the cost of solar PV. More traditional resources, such as a conventional coal-fired facility and a conventional combustion turbine, featured levelized power costs of approximately \$100/MWh and \$140/MWh, respectively. (Note: the EIA's *Annual Energy Outlook 2010* assumes a carbon tax of \$15 per ton of carbon dioxide. If this cost were removed, the levelized price of conventional coal-fired generation in the study would be less than \$90/MWh without additional pollution controls.)

2.3 Renewable Portfolio Standards

A renewable portfolio standard (RPS) is a mandate requiring utilities and retail electric providers to produce a specified percentage of their electricity from approved renewable energy sources. No federal RPS exists in the United States; however, 29 states plus the District of Columbia have implemented an RPS in their state while six others have passed goals for renewable energy utilization. A map detailing the status of the state renewable portfolio standards throughout the United States, as well as a table highlighting the objectives of each state, are included in Appendix D.

Reasons for implementation of an RPS vary from state to state. Perhaps the most common driver is a reduction in greenhouse gas emissions. Greenhouse gases, such as carbon dioxide (CO_2) and methane (CH_4), are emitted from the combustion of fossil fuels like coal. However, although GHG reduction constitutes one important benefit from greater use of renewable energy and has been an important consideration, in many instances climate benefits are deemed ancillary to a variety of economic advantages and political pressures. As an example, for states frustrated with the unanticipated volatility in natural gas prices over the past half-decade, the prospect of more predictable generation costs through renewables is increasingly attractive (Rabe 2006). Moreover, virtually every governor has now embraced the notion of developing "home grown" energy sources, at least in part, in order to foster long-term economic development in their state (Rabe 2008). Despite the motivations for an RPS, its purpose is clear. A well-designed RPS should generally encourage competition among renewable developers and provide incentives to electricity suppliers to meet their renewable purchase obligations in a least-cost fashion (Chen, Wiser and Bolinger 2007).

No two states are equally endowed with the same renewable resources. As a result, a total lack of homogeneity exists between state renewable portfolio standards. Minimum percentages, deadlines, and even approved renewable sources vary in every state. For instance, all existing state standards classify solar, biomass, wind, and geothermal power as renewables, after which politics step in. Some disallow certain types of biomass, at least nine disqualify trash burning, and admissible fuel cell technologies vary widely (Michaels 2008). The design and objectives of current renewable portfolio standards rarely transcend state boundaries.

There is also significant disagreement throughout the industry regarding the general effectiveness of renewable portfolio standards. State studies comparing the costs and benefits of different target percentages and dates are rare or nonexistent. In turn, a number of states have faced early implementation problems, ranging from local resistance to the siting of renewable generating facilities or transmission lines to political pressure from supporters of particular renewable energy sources to receive increasingly favored treatment in RPS implementation (Rabe 2008).

Estimates of economic impacts stemming from renewable portfolio standards are also wildly diverse. In a report from Lawrence Berkeley National Laboratory (LBNL), a national laboratory of the Department of Energy, 28 studies covering 18 states were reviewed and summarized for their RPS economic impacts (Chen, Wiser and Bolinger 2007). On the whole, state-RPS-induced rate impacts were typically projected to be relatively modest with more than half of the reviewed studies reporting base-case rate increases of less than one percent. Conversely, nine studies predicted rate increases in excess of one percent, two of which showed an increase of greater than five percent. It is worth noting that the study with the highest estimated rate increase was prepared by Pacific Energy Group for the state of Arizona and included the largest integration of solar energy of any study considered by LBNL.

As an additional reference, a comparable study was performed by the Heritage Foundation, a private research and educational institution. According to their report, a federal RPS would increase electricity prices by 36 percent for the average household; the country's gross domestic product (GDP) would be cut by $5.2 trillion between 2010 and 2035; national income would fall by $2,400 per year per family of four; employment would be reduced by more than one million jobs; and more than $10,000 would be added to a family of four's share of the national debt by 2035 (Kreutzer, et al. 2010). Needless to say, very little consistency is observed regarding the perceived economic impacts of a renewable portfolio standard.

2.4 Solar Energy Carve-Outs

Many discussions of renewable portfolio standards start from an artificial distinction that some renewable resources are better than others. This is especially true with solar energy. As of September 2010, 16 states plus the District of Columbia had added provisions to their RPS to specifically advance the use of solar energy. The most common of these, a solar carve-out, requires that a minimum percentage of the

RPS be generated by solar resources. Figure 17 in Appendix D presents a visual representation of the current state renewable portfolio standards with solar carve-out provisions.

Many states, such as Michigan and Utah, include multipliers which provide additional credit to those who use solar over other resources. However, numerous studies have been conducted on the effectiveness of these multipliers, each showing that multipliers are not a successful tool for supporting solar energy (Kubert and Sinclair 2010). Although several states continue to offer the multiplier as a means of enticing solar production, it is generally well-accepted that this incentive is ineffective. As such, this report will focus solely on solar carve-outs and will exclude further discussions of multipliers.

The following sections outline many of the common advantages and goals cited in support of solar carve-outs. Where appropriate, typical counterarguments on this subject are also included.

2.4.1 Economies of Scale

The most commonly-cited goal of a carve-out is to promote solar energy use and introduce economies of scale to make the resource more cost competitive. According to estimates from Lawrence Berkeley National Laboratory, carve-out compliance will result in 400 megawatts (MW) of solar by 2010 and 2,000 MW by 2015 (Kubert and Sinclair 2010). By 2025, LBNL estimates that nearly 9,000 MW of solar capacity will be required for compliance with these mandates (SEIA 2010). Those in support of solar carve-outs are hopeful that these dramatic increases in scale will improve the learning curve for solar power, leading to drastic improvements in efficiency and reductions in installed costs that currently are as much as 250 percent higher than other types of renewable energy.

To illustrate the advantage of promoting solar energy use, many point to Germany as an example of success. Germany leads the world in solar PV capacity with more than 3,800 MW installed by year-end 2009 despite having a worse solar resource than any U.S. state other than Alaska (SEIA 2010) (see Figure 15 in Appendix C for a solar insolation map of Germany). However, Germany has not achieved this milestone through an RPS or solar carve-out. Instead, feed-in tariffs (FIT) have led to an outpouring of support in that country for photovoltaic resources. The German FIT, representing a minimum rate that utilities must pay generators for energy, starts as high as €329/MWh, or approximately $425/MWh (Gipe 2010). The German government estimated that each German household paid an additional €2.10 per month (or approximately $33 per year) on their electric bills to cover the costs of the 53.4 TWh eligible for the tariff (National Research Council 2010, 154).

Despite leading the world in solar photovoltaic capacity, the resulting generation in Germany is not equal in magnitude. In 2008, solar energy accounted for less than one percent of Germany's total generation (EIA-a 2009). This statistic is a painful illustration of the poor efficiency and intermittent output that accompany current solar technologies.

Within the United States, the state most commonly referenced as an example of the effectiveness of the solar carve-out is New Jersey. Current RPS requirements in New Jersey call for 5,316 gigawatt-hours (GWh) of solar energy by 2025-2026 (DSIRE-a 2010). However, despite having a modest solar resource, New Jersey is second only to California in installed solar capacity. The aggressive approach to increasing the use of solar resources in New Jersey has not come without consequences. As an enforcement mechanism for solar carve-out compliance in New Jersey, a solar alternative compliance payment (SACP) is in place. In 2009, the SACP price reached $711 per MWh, meaning any entity not in compliance for solar energy generation was required to pay that amount for all deficit energy (Kubert and Sinclair 2010).

Two critical pieces of information may be gleaned from New Jersey's SACP. First, the SACP is designed to encourage the installation of solar infrastructure. As such, the SACP is typically set slightly higher than the expected cost of generating solar energy so that it is less expensive for a generator to be in compliance than to pay penalties. At more than $700 per MWh, or nearly double the national average levelized cost of solar PV generation, New Jersey is paying a significant premium to encourage solar energy development.

The second key piece of information to be deduced from the New Jersey SACP is the rate at which it declines. After 2009, the SACP decreases by three percent per year (Kubert and Sinclair 2010). This value should be indicative of the rate at which legislators expect costs of solar energy to decline; if not, there would be little incentive to not simply pay the compliance penalty. At three percent per year, legislators have indicated that they expect solar costs in New Jersey to actually decline 0.6 percent slower than the average over the previous decade despite a significant increase in installed capacity (Greentech Media 2009). As such, New Jersey legislators are not publically conveying confidence that the solar carve-out in their state will be as effective as advertised.

2.4.2 Diversification

Another noteworthy advantage cited when considering a solar carve-out is diversification in an entity's generation mix. Few argue the importance of a diverse energy portfolio. However, it should not be the role of politicians to dictate this mix. In states like New Jersey where solar resources are significantly less attractive than many southwestern states, solar energy is being forced into an energy mix where it is not cost competitive with other resources. The result is essentially a mandatory, non-debatable fee on customers to support solar energy.

Moreover, low capacity factors from solar resources necessitate significantly more capacity to produce comparable levels of generation from other resources. For instance, as mentioned in Section 2.4.1, New Jersey's RPS calls for 5,316 GWh of solar generation by 2025-2026. Assuming an 18 percent capacity factor for solar PV in that state (a potentially aggressive assumption), nearly 3,400 MW of solar capacity would need to be installed to reach that generation total. Nearly half that capacity would be required if wind generation were eligible. Although using a diverse mix of generation resources has merit, requiring a resource that costs three to five times as much as other renewable alternatives and necessitates twice as much installed capacity is both excessive and insensitive to those who must pay for these mandates.

A final argument in favor of diversification through solar carve-outs hinges on energy security. Like before, few argue the importance of a diverse generation portfolio. A utility that were to install their entire fleet at a single location or rely exclusively on a single fuel source would be both negligent and senseless. However, there are few, if any, important relationships between renewables and energy security in the United States outside of the transportation sector (Michaels 2008). Security centers on oil; however, less than two percent of the nation's electric power comes from oil and, even at anticipated capacity levels expected from carve-outs, solar power is not expected to comprise a significant percentage of the nation's electric portfolio. Thus, although there are advantages to diversification, energy security is an ancillary benefit at best.

2.4.3 Green Jobs

A final common benefit of solar carve-outs is the creation of jobs. During a time of significant economic uncertainty in the United States, many governors have embraced opportunities to foster long-term economic development in their states. According to one study, every megawatt of solar energy creates 33 jobs in installations, two jobs in research, and an additional 10 jobs in production (EPIA 2008).

However, what few governors fail to convey is the quid pro quo relationship that exists between job creation and solar energy mandates. Typical solar capacity factors are nearly half of those observed for wind power facilities, a third of the capacity factor of many hydroelectric facilities, and barely a quarter of a geothermal facility's typical capacity factor. The fundamental point is that solar facilities must be significantly overbuilt relative to other renewable resources to produce the same amount of generation. Thus, despite the large number of jobs created by the industry, this benefit is being heavily subsidized by rate payers who must support among the most expensive and inefficient renewable alternatives.

2.5 Summary and Conclusions

Many current renewable portfolio standards mandate the use of specific technologies, most notably solar power. By requiring the use of this resource, legislators are hopeful that solar energy can become a more efficient and cost-competitive resource while simultaneously bringing many economic benefits to their states. However, this shift towards differential treatment of resources has moved some of the recent debate over renewable energy policy in state capitals toward a collision between competing special interests, each seeking preferential treatment (Rabe 2006).

The underlying objective of a solar carve-out may have merit. However, rather than specifying a winning technology, state legislators would be better served to instead outline the goals of their renewable energy policy – reduce pollution and greenhouse gas emissions, improve power quality, maintain electric supply reliability, and control costs – and provide incentives to reach them (Apt, Lave and Pattanariyankool 2008). No current technology satisfies all of these goals. Thus, legislators must allow for tradeoffs and leave the means of realizing the goals to technologies and the market. By specifying the goals rather than the technologies, they may create a technology race that will serve society far better than current legislation.

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Chapter 3 - Overview of Study Investigations

Although numerous states have implemented a solar carve-out through their state RPS, few have conducted detailed analyses to ascertain the viability or impacts of these mandates. These policies have largely been implemented without evaluations supporting their merit or effectiveness. Instead, politicians have chosen to support an artificial distinction that solar is a better form of energy than other renewable resources. Although the amount of solar energy that is being required through this legislation is relatively small, its impact may be both direct and far-reaching.

The objective of this study is to provide a comprehensive and critical review of solar energy carve-outs in renewable portfolio standards. To this end, three independent yet collaborative investigations were undertaken. To provide the reader with an outline of these investigations and their underlying function in this study, a general synopsis of each is included below. Note that the purpose of this report section is simply to provide a general outline of the investigations that were conducted; detailed summaries of methodology and results for each investigation are provided in the chapters that follow.

- **Investigation 1 - Characterization of Carve-Out States:** Before investigating how solar energy carve-outs may impact various states, this investigation aims to characterize these states in order to understand why this legislation is being promoted.
- **Investigation 2 - National Differential Analysis:** The purpose of this investigation is to present a generalized assessment of the economic viability of utilizing solar energy throughout the United States. By comparing solar energy to more traditional, cost-competitive renewable resources, a national differential analysis is prepared to demonstrate the economic impacts of large-scale solar energy utilization.
- **Investigation 3 - State Case Studies:** With the first two investigations as a basis, the final investigation provides a case study of three states that have implemented solar energy carve-outs.

> The focus of these case studies is centered on the economic implications of solar carve-outs and the potential environmental benefits derived from them.

As of August 2010, 16 states plus the District of Columbia had added carve-out provisions to their RPS. These provisions generally include explicit solar energy carve-outs and/or distributed generation stipulations. For purposes of this study, only those (14) states with explicit solar energy carve-outs were evaluated in the three aforementioned investigations. To ensure a clear understanding, the following states are collectively referred to as "carve-out states" from this point forward:

1. Delaware
2. Illinois
3. Maryland
4. Massachusetts
5. Missouri
6. Nevada
7. New Hampshire
8. New Jersey
9. New Mexico
10. North Carolina
11. Ohio
12. Oregon
13. Pennsylvania
14. District of Columbia

The remaining (37) states are collectively referred to as "non-carve-out states" and, where appropriate, totals for the entire United States are provided under the term "all states".

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Chapter 4 - Characterization of Carve-Out States (Investigation 1)

Before investigating how solar energy carve-outs may impact various states, it is important to first generate an understanding about why these policies are being implemented. Many theories have been postulated on this subject, although few provide formal support for their arguments. The purpose of this investigation was to comprehensively evaluate those states that have implemented a solar energy carve-out in an attempt to characterize the underlying drivers that are motivating this legislation.

4.1 Investigation Overview

For this investigation, five factors were evaluated in all 50 states plus the District of Columbia in order to characterize differences between states that have adopted a solar energy carve-out and those that have not. These factors include each state's energy generation portfolio; existing electric rates; energy consumption; air quality standards; and measurable wealth. Although other drivers may be at play, most notably including environmental politics, these factors are not directly quantifiable and were intentionally excluded from this analysis.

4.2 Generation Portfolio

The following sections detail the methodology and results from the evaluation of state generation portfolios.

4.2.1 Methodology

The first factor evaluated in this investigation was the most recent mix of electric generation resources in each state. The purpose of this evaluation was to uncover potential differences in the generation portfolio of carve-out states, such as a greater dependence on fossil fuels or an existing focus on renewable energy. The results of this analysis may indicate a motivation to diversify the state's energy resources as a driver for solar carve-out legislation.

Data was collected from the Energy Information Administration, a statistical agency of the United States' Department of Energy, regarding the net energy generation throughout the United States. This data was then segregated by state and fuel type for this evaluation. Due to delays in reporting, the most recent full year of information available was from 2009.

A detailed summary of data utilized for this evaluation, including source information on the 11 individual EIA sources used to extract this information, is provided in Table 19 in Appendix E.

4.2.2 Results

A summary of the generation portfolio evaluation completed as part of this investigation is provided in Table 1.

Table 1. Generation Portfolio Summary

Total 2009 Generation (% of Total Net Generation)	Carve-Out States	Non-Carve-Out States	All States
Coal	51.2%	43.8%	45.8%
Petroleum Liquid	0.6%	0.9%	0.9%
Petroleum Coke	0.1%	0.3%	0.3%
Natural Gas	12.3%	23.7%	20.5%
Other Gases	0.1%	0.3%	0.3%
Nuclear	28.2%	18.3%	21.1%
Hydro (Conventional)	5.2%	7.8%	7.1%
Other Renewables	2.0%	4.6%	3.9%
Other	0.2%	0.3%	0.3%

The following is a list of notable observations from the results of this analysis:

- More than 51 percent of all energy in carve-out states is produced from coal. This is approximately 7.4 percent higher than non-carve-out states and 5.4 percent higher than the national average. This dependency on coal-fired generation in carve-out states supports the hypothesis that diversification may be a key driver in support of carve-out legislation.

- Only 2.0 percent of all energy in carve-out states is produced from non-hydroelectric renewable resources. This is approximately half of the national average (3.9 percent) and signals a clear lack of emphasis on renewable energy generation in these states.
- Approximately 79.4 percent of carve-out state generation is produced by coal-fired and nuclear resources, roughly 12.5 percent higher than the national average. Coal and nuclear generation facilities are baseload resources that typically operate at full output. With such a significant portion of their total generation portfolio produced from these fuel types, carve-out states may encounter significant obstacles relating to electric transmission as their percentage of generation from renewable energy resources increases.

There is a clear dependency on coal-fired generation in carve-out states and a notable shortage in the utilization of renewable resources. As fossil fuel-fired resources continue to come under intense scrutiny, these factors indicate that regulators may be using carve-out legislation as a means of diversifying their state's generation portfolio with increased levels of renewable energy while hoping to simultaneously decrease their reliance on fossil fuels.

4.3 Electric Rates

The following sections detail the methodology and results from the evaluation of state electric rates.

4.3.1 Methodology

The second factor considered in this investigation was the cost of electricity in each state. The purpose of this evaluation was to uncover potential differences in the cost of energy in carve-out states, most notably in terms of residential electric rates. If customers in these states are inherently paying higher fees for electricity, the results of this analysis may point to a diminished concern relating to the increased cost of solar energy relative to other renewable resources.

Data was collected from the EIA detailing the average retail electric rates paid in each state. These rates were segregated by sector (residential, commercial, industrial) and represent actual kilowatt-hour (kWh) rate data from 2009.

A detailed summary of data utilized for this evaluation, as well as pertinent source information, is provided in Table 20 in Appendix E.

4.3.2 Results

A summary of the electric rates evaluation completed as part of this investigation is provided in Table 2.

Table 2. Electric Rates Summary

Electric Rates ($/kWh)	Carve-Out States	Non-Carve-Out States	All States
Average Residential Rates	$0.1227	$0.1103	$0.1123
Average Overall Rates	$0.1095	$0.0948	$0.0972
Median Residential Rates	$0.1198	$0.0960	$0.0995
Median Overall Rates	$0.0963	$0.0816	$0.0873

The following is a list of notable observations from the results of this analysis:

- Residential electric rates in carve-out states are, on average, 11.3 percent higher than non-carve-out states and 9.3 percent higher than the national average.
- Overall electric rates (including commercial and industrial customers) in carve-out states are, on average, 15.5 percent higher than non-carve-out states and 12.6 percent higher than the national average.
- The median residential electric rate ($0.1198/kWh) in carve-out states is 24.8 percent higher than non-carve-out states and 20.4 percent higher than the national average.

There is a significant disparity in electric rates between carve-out states and all others. Customers in carve-out states are paying drastically more for electricity than their counterparts in non-carve-out states.

The impact of this fact is likely two-fold. First, the inherently-higher cost of solar energy relative to any other form of generation will likely not carry the same significance in these states since they have already become accustomed to paying a premium for energy. Second, the aggregate economic impact of solar carve-outs in these states may be diminished; that is, forcing an expensive generation resource into an already expensive generation portfolio will have a lessened impact on residential rates than if solar carve-out legislation was added to a state with low electric rates.

4.4 Energy Consumption

The following sections detail the methodology and results from the evaluation of trends in state energy consumption.

4.4.1 Methodology

The third factor considered in this investigation was the rate at which energy is consumed in each state. The purpose of this evaluation was to uncover potential differences in the rate at which energy is imported to or exported from carve-out states. Higher electric rates would likely correlate with a higher percentage of net imports and, as before, the results of this analysis may point to a diminished concern relating to the increased cost of solar energy relative to other renewable resources.

Data for this evaluation was collected from two sources. First, information from the EIA relating to total state energy consumption was utilized. This information centered on the net interstate flow of electricity in each state, or the difference in the amount of electricity sold within a state (including associated losses) and energy input at the electric utilities within a state. A positive number for this category indicates that more electricity came into a state (import) than went out (export). Due to delays in reporting, the most current full year of information available for this assessment was from 2008.

The second piece of critical information for this analysis was from the United States Census Bureau. Based on 2008 population estimates, a per capita consumption rate was calculated for each state, highlighting the total energy consumption per person in 2008.

A detailed summary of data utilized for this evaluation, including pertinent source information, is provided in Table 21 in Appendix E.

4.4.2 Results

A summary of the energy consumption evaluation completed as part of this investigation is provided in Table 3.

Table 3. Energy Consumption Summary

Net Energy Consumption (2008)	Carve-Out States	Non-Carve-Out States	All States
Average Energy Consumption (Trillion Btu)	1,822	1,995	1,948
Net Interstate Flow of Electricity (Trillion Btu)	-195	195	0
Per Capita Energy Consumption (MMBtu/Person)	300	405	327

The following is a list of notable observations from the results of this analysis:

- As expected, the high electric rates in carve-out states correlate with a high percentage of net imports. The total net interstate flow of electricity in carve-out states is negative, indicating a net import of 195 trillion Btu of energy in 2008.
- Average energy consumption in carve-out states is 1,822 trillion Btu per year, or approximately 8.7 percent lower than non-carve-out states and 6.5 percent lower than the national average.
- Per capita energy consumption in carve-out states is 26 percent lower than in non-carve-out states and 8.4 percent lower than the national average.

Carve-out state residents consume considerably less energy (on average and per capita) than their counterparts. However, carve-out states must still import a significant portion of their overall electricity requirements. These factors likely highlight the political nature of carve-out legislation, using the policies as a means of increasing in-state industry and promoting local job growth.

4.5 Air Quality

The following sections detail the methodology and results from the evaluation of state air quality.

4.5.1 Methodology

The fourth factor considered in this evaluation was relative air quality in each state. The purpose of this evaluation was to determine if carve-out states had measurably better or worse air quality than non-carve-out states. Demonstrably inferior air quality may indicate a focus on the environmental attributes of renewable energy and, more specifically, a perception that solar energy provides greater environmental benefits than other renewable resources.

Two measures of air quality were incorporated into this evaluation. In the first, carbon dioxide emissions were analyzed for each state. This included a review of annual CO_2 emissions by state, as well as a calculation of per capita CO_2 emissions. Based on delays in reporting to the Energy Information Administration, the most recent year of CO_2 emissions data available was from 2007. A detailed summary of data utilized for this evaluation, including pertinent source information, is provided in Table 22 in Appendix E. Finally, note that because of the lack of physical generation resources in the District of Columbia, Washington D.C. was excluded from this analysis to avoid artificially skewing the merit of the results.

The second measure of air quality considered for this analysis was the extent of nonattainment areas, or regions where ambient ground-level concentrations of one or more criteria pollutants are higher than the National Ambient Air Quality Standards (NAAQS) as established by the Environmental Protection

Agency (EPA) (EPA-a 2010). The Clean Air Act, which was last amended in 1990, requires the EPA to set NAAQS for pollutants considered harmful to public health and the environment. These pollutants include carbon monoxide (CO), lead (Pb), nitrogen oxides (NO_x), particulate matter of 2.5 microns in diameter or smaller ($PM_{2.5}$), particulate matter of 10 microns in diameter or smaller (PM_{10}), ozone (O_3), and sulfur oxides (SO_x). A current listing of nonattainment areas for each state, as provided in detail in Table 23 in Appendix E, was used for this evaluation.

4.5.2 Results

A summary of the air quality evaluation completed as part of this investigation is provided in Table 4.

Table 4. Air Quality Summary

Air Quality Measures (2007)	Carve-Out States	Non-Carve-Out States	All States
Total Annual CO_2 Emissions (MMT)	1,558	4,395	5,955
Average Annual CO_2 Emissions (MMT)	119.8	118.8	119.1
Per Capita CO_2 Emissions (MMT)	20.7	22.2	21.8
States Containing Nonattainment Areas (%)	85.7%	56.8%	64.7%

Note: Summary Excludes Washington D.C.

The following is a list of notable observations from the results of this analysis:

- Average annual CO_2 emissions in carve-out states are approximately 0.9 percent higher than in non-carve-out states and 0.6 percent higher than the national average. These differences are considered negligible.
- Per capita CO_2 emissions in carve-out states are 6.8 percent lower than in non-carve-out states and 5.0 percent lower than the national average.
- 85.7 percent of carve-out states have at least one region designated as being in nonattainment, compared to 56.8 percent in non-carve-out states and 64.7 percent nationally. However, this statistic is largely regional and is likely not correlated to carve-out legislation.

Although the results of this evaluation are statistically-based, it is important to realize that results may be skewed by the physical location of generating resources. Considering that electricity regularly crosses state boundaries, energy may be produced and emissions released in one state while the electricity is consumed in another. Moreover, emissions values may also be largely influenced by the transportation sector in a state, meaning results may not be indicative of issues relating directly to electricity generation. Because of these considerations and due to the largely non-indicative nature of the results from this analysis, these results are given minimal weight hereafter.

4.6 Wealth

The following sections detail the methodology and results from the evaluation of state wealth.

4.6.1 Methodology

The fifth and final factor considered in this evaluation was the relative economic health of each state. The purpose of this evaluation was to determine if carve-out states are measurably wealthier than non-carve-out states. Similar to the electric rates (Section 4.3) and energy consumption (Section 4.4) analyses, a higher level of overall wealth may point to a diminished concern relating to the increased cost of solar energy relative to other renewable resources.

To complete this evaluation, data on median household income and gross domestic product for each state were gathered from the U.S. Census Bureau. These measurables are typically strong indicators of the overall financial strength of a state.

A detailed summary of data utilized for this evaluation, including pertinent source information, is provided in Table 24 in Appendix E.

4.6.2 Results

A summary of the state wealth evaluation completed as part of this investigation is provided in Table 5.

Table 5. Wealth Summary

Measures of State Wealth (2008)	Carve-Out States	Non-Carve-Out States	All States
Median Household Income	$67,800	$62,169	$62,902
Average State Gross Domestic Product ($MM)	$285,823	$274,704	$277,756
Per Capita GDP	$56,550	$44,714	$46,605

The following is a list of notable observations from the results of this analysis:

- Median household income in carve-out states is 9.1 percent higher than in non-carve-out states and 7.8 percent higher than the national average. This represents a significant disparity.
- The mean GDP in carve-out states is 4.0 percent higher than in non-carve-out states.
- The per capita GDP in carve-out states is 26.5 percent higher than in non-carve-out states and 21.3 percent higher than the national average.

The economies of carve-out states are significantly stronger than both non-carve-out states and the national average. Residents of these states also enjoy notably higher pay than their counterparts in non-carve-out-states. Like previous analyses conducted through this investigation, these factors support the suggestion that the higher level of overall wealth in these states will diminish the perceived aggregate economic impact of solar carve-out legislation.

4.7 Summary and Conclusions

This investigation uncovered several key characteristics of states that have enacted solar carve-out legislation. Perhaps the most important of these focuses on economics. Residents in carve-out states are markedly wealthier than their non-carve-out state counterparts. Moreover, these residents are also accustomed to paying more for electricity. Thus, despite the high premium these states will pay for solar energy in order to support carve-out legislation, the aggregate impact of the legislation in these states may be diminished. That is, forcing an expensive generation resource into an already expensive generation portfolio will have a smaller impact than if carve-out legislation were enacted in a state with inherently low electric rates or a weak economy.

Another key characteristic of carve-out states is the way in which they produce electricity. Carve-out states are heavily dependent on coal-fired resources and have a notable shortfall in total generation from renewables. Fossil fuels, especially coal, have come under great scrutiny in recent years due to the release of GHG emissions that accompanies their combustion. As the debate on global climate change continues, so too will the focus on the use of these resources. As such, regulators are likely aiming to use carve-out legislation to decrease their state's reliance on fossil fuels while simultaneously diversifying their state's generation portfolio with increased levels of renewable energy.

A final key characteristic of carve-out states is their pattern of electricity consumption. As a whole, carve-out states are importing significant quantities of energy from other states. Legislators likely recognize this fact and may be using carve-out legislation as an opportunity for political gain. By implementing solar carve-outs and requiring generation from within their state's borders, these policies are being used to increase in-state industry and promote local job growth in lieu of any negative attributes that may accompany them.

This investigation identified several clear and statistically-based characteristics of carve-out states. In the following chapter, the economic viability of solar energy is evaluated in further detail.

* * * * *

Chapter 5 - National Differential Economic Analysis (Investigation 2)

No two states are equally endowed with the same renewable resources. As shown previously, the preeminent solar resources in the United States occur in the southwestern part of the country. Similarly, geothermal resources are commonly restricted to the western United States while the greatest wind resources are typically in the Midwest. Although renewable energy can generally be developed in any state, the effectiveness of that resource – both in terms of economics and performance – may vary dramatically with location.

To understand how the attractiveness of solar energy varies from state-to-state, a national differential economic analysis was performed. The objective of this evaluation was to offer a generalized, national overview of the economic impacts of requiring the use of solar energy compared to more traditional, cost-competitive renewable resources. For this evaluation, wind energy was chosen as the basis of comparison due to its status as the most prevalent non-hydroelectric renewable resource. Moreover, much like solar energy, wind resources are adaptable to a variety of locations. As such, a direct comparison between these alternatives was deemed to be appropriate for this evaluation.

5.1 Investigation Overview

This investigation was completed in two parts. In the first, regional capacity factors for both wind and solar energy were characterized. This data was subsequently utilized in the second part of this evaluation in which pro forma financial models were used to assess the economic viability of each type of renewable energy considered, as well as to develop an estimate for the “premium” paid for solar energy relative to wind. The following sections detail the methodology utilized in each part of this evaluation, as well as the results and associated conclusions that were gleaned from it.

5.2 Capacity Factor Characterization

Perhaps the most influential factor on the economics of any renewable energy project is that project's capacity factor. Thus, it is important to accurately quantify the capacity factors expected from both wind and solar energy before completing any financial analyses. The following sections detail the methodology utilized in the characterization of regional capacity factors for this study.

5.2.1 Wind Energy Capacity Factors

Through its *Wind Powering America* initiative, the National Renewable Energy Laboratory (NREL) completed a comprehensive assessment of wind energy potential throughout the contiguous United States in February 2010 (note that Mississippi, Alaska, and Hawaii were excluded from that study). As part of their assessment, NREL estimated the available "windy land area" for each state, or the amount of land that could potentially be developed for its wind resources and that would perform at least at a minimum threshold or better. After excluding areas unlikely to be developed, such as wilderness areas, parks, urban areas, and water features, the energy potential of the windy land areas was estimated by NREL (NREL-a 2010). A summary of the wind energy potential derived by NREL for each state is included in Table 25 in Appendix F.

An independent estimation of wind energy capacity factors was not considered vital to this analysis. As such, NREL estimates for installed capacity and annual generation on windy land areas were utilized to produce approximations of gross capacity factors (GCF) for each state. A summary of the statewide gross capacity factors developed for this evaluation is presented in Figure 3. A full listing of these estimates is also included in Table 26 in Appendix F.

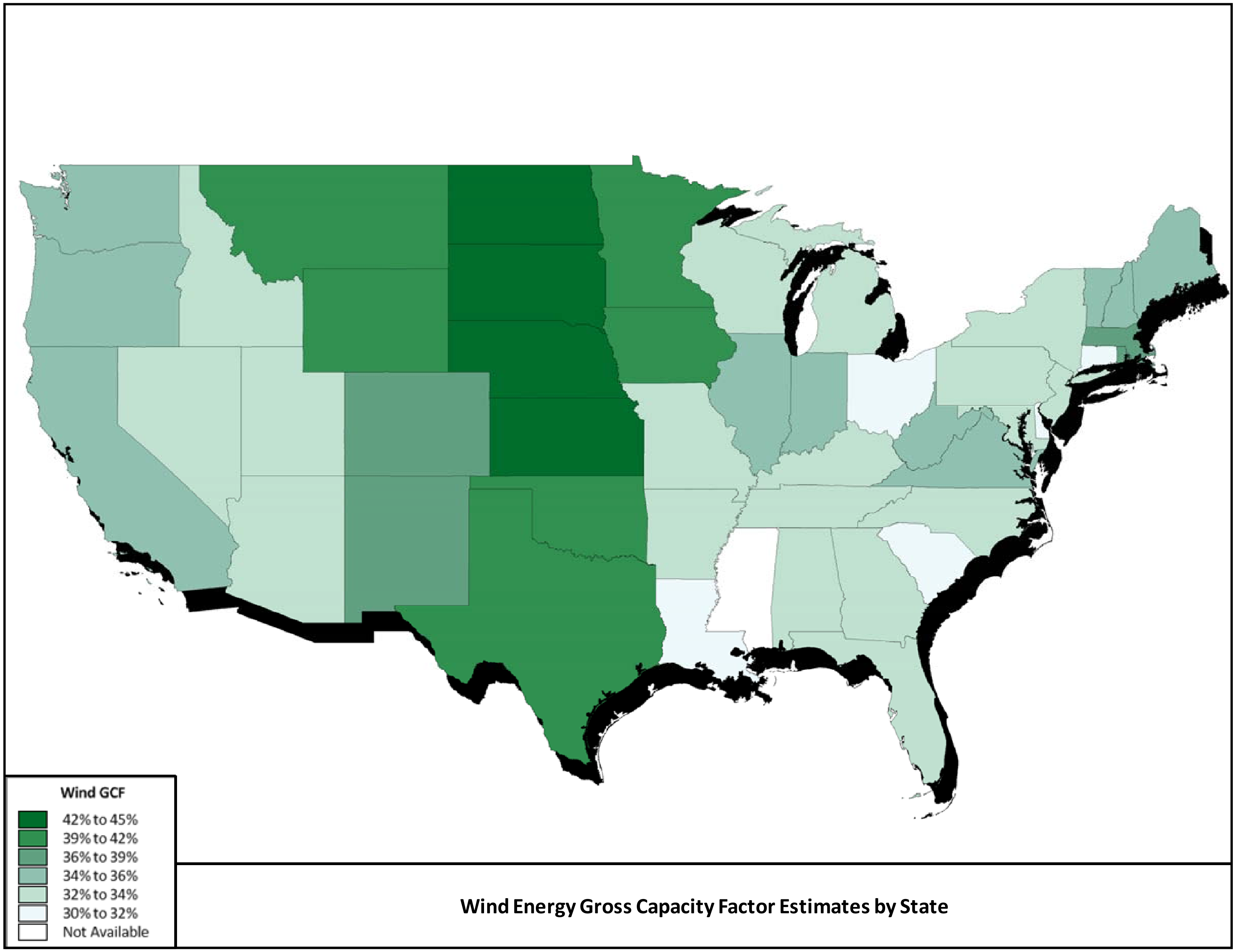

Figure 3. Wind Energy Gross Capacity Factor Estimates by State

5.2.2 Solar Energy Capacity Factors

The initial step in preparing capacity factor estimates from solar energy resources was an assessment of the average annual solar insolation in each state. Using PVWatts (version 2), an NREL-developed model for determining energy production for grid-connected solar PV systems, estimates of the performance of a hypothetical PV installation were prepared for each state.

The PVWatts calculator uses typical meteorological year (TMY) weather data for a selected location to determine the solar radiation incident on the PV array, as well as the PV cell temperature, for each hour of a year. The direct-current (DC) energy for each hour is then calculated from the DC rating of the photovoltaic system and the incident solar radiation and is subsequently corrected for the PV cell temperature. Finally, hourly alternative-current (AC) energy is calculated by multiplying the DC energy by a DC-to-AC derate factor and adjusting for inverter efficiency as a function of load (NREL-b 2010). These hour-by-hour performance simulations are used to provide annual energy production estimates for a selected location.

Two system configurations were evaluated within PVWatts for this evaluation. Fixed-tilt systems were considered because they are most representative of residential systems and typically feature the lowest capital costs for solar installations. Second, single-axis tracking systems were also evaluated. Although tracking systems are often notably more expensive than fixed-tilt configurations, they can produce significantly more energy and were intended to represent commercial and industrial installations. Dual-axis tracking systems may also be modeled within PVWatts; however, the incremental gain in efficiency is often not sufficient to justify the increased costs of these systems, so no effort was made to evaluate these solar configurations.

Within PVWatts, system parameters for size, array type, tilt angle, azimuth angle, and more may be specified by the user. Below is a list of the non-default parameters specified within the tool for each configuration:

PVWatts Parameter	**Parameter Value**
• DC Rating	1.0 kW
• DC-to-AC Derate Factor	0.80
• Array Type	
o Configuration 1	Fixed Tilt
o Configuration 2	1-Axis Tracking

In each of the lower 48 states, a representative location was selected for this evaluation, meaning a location with solar resources that were indicative of a statewide average. Using PVWatts and the aforementioned parameters, energy estimates were produced for each array type and state. From these values, a gross capacity factor was calculated. A detailed listing of these solar energy and gross capacity factor estimates are provided in Table 6.

Table 6. Solar Energy Gross Capacity Factor Estimates by State

State	Location	Configuration 1 (Fixed Axis) Average Annual Solar Insolation (kWh/m²/yr)	Configuration 1 (Fixed Axis) Annual AC Energy (kWh)	Configuration 1 (Fixed Axis) Gross Capacity Factor (%)	Configuration 2 (Single-Axis Tracking) Average Annual Solar Insolation (kWh/m²/yr)	Configuration 2 (Single-Axis Tracking) Annual AC Energy (kWh)	Configuration 2 (Single-Axis Tracking) Gross Capacity Factor (%)
Alabama	Birmingham, AL	4.91	1,310	15.0%	6.02	1,625	18.6%
Arizona	Phoenix, AZ	6.29	1,607	18.3%	8.15	2,103	24.0%
Arkansas	Little Rock, AR	4.96	1,324	15.1%	6.19	1,675	19.1%
California	San Diego, CA	5.74	1,539	17.6%	7.08	1,918	21.9%
Colorado	Colorado Springs, CO	5.54	1,554	17.7%	7.11	2,024	23.1%
Connecticut	Hartford, CT	4.22	1,168	13.3%	5.10	1,434	16.4%
Delaware	Dover, DE	4.69	1,275	14.6%	5.77	1,597	18.2%
Florida	Miami, FL	5.21	1,377	15.7%	6.41	1,717	19.6%
Georgia	Atlanta, GA	4.96	1,333	15.2%	6.13	1,667	19.0%
Idaho	Boise, ID	5.19	1,405	16.0%	6.78	1,863	21.3%
Illinois	Springfield, IL	4.70	1,287	14.7%	5.87	1,635	18.7%
Indiana	Indianapolis, IN	4.49	1,233	14.1%	5.52	1,535	17.5%
Iowa	Des Moines, IA	4.87	1,351	15.4%	6.14	1,724	19.7%
Kansas	Topeka, KS	5.20	1,427	16.3%	6.55	1,819	20.8%
Kentucky	Louiville, KY	4.67	1,265	14.4%	5.78	1,583	18.1%
Louisiana	New Orleans, LA	4.93	1,300	14.8%	6.01	1,608	18.4%
Maine	Augusta, ME	4.32	1,216	13.9%	5.35	1,526	17.4%
Maryland	Baltimore, MD	4.80	1,308	14.9%	5.93	1,644	18.8%
Massachusetts	Boston, MA	4.16	1,162	13.3%	5.11	1,447	16.5%
Michigan	Detroit, MI	4.81	1,161	13.3%	5.12	1,441	16.4%
Minnesota	Minneapolis, MN	4.54	1,273	14.5%	5.69	1,617	18.5%
Missouri	Kansas City, MO	5.02	1,376	15.7%	6.29	1,744	19.9%
Montana	Helena, MT	4.82	1,337	15.3%	6.20	1,743	19.9%
Nebraska	Lincoln, NE	5.06	1,395	15.9%	6.34	1,765	20.1%
Nevada	Las Vegas, NV	6.29	1,637	18.7%	8.28	2,177	24.9%
New Hampshire	Concord, NH	4.33	1,207	13.8%	5.37	1,516	17.3%
New Jersey	Trenton, NJ	4.48	1,226	14.0%	5.48	1,525	17.4%
New Mexico	Albuquerque, NM	6.02	1,620	18.5%	7.77	2,119	24.2%
New York	New York, NY	4.60	1,275	14.6%	5.59	1,571	17.9%
North Carolina	Charlotte, NC	4.91	1,317	15.0%	6.05	1,638	18.7%
North Dakota	Bismark, ND	4.84	1,361	15.5%	6.15	1,750	20.0%
Ohio	Columbus, OH	4.27	1,170	13.4%	5.23	1,450	16.6%
Oklahoma	Oklahoma City, OK	5.33	1,447	16.5%	6.75	1,855	21.2%
Oregon	Eugene, OR	4.20	1,129	12.9%	5.29	1,448	16.5%
Pennsylvania	Pittsburgh, PA	4.08	1,114	12.7%	4.95	1,368	15.6%
Rhode Island	Providence, RI	4.32	1,206	13.8%	5.26	1,489	17.0%
South Carolina	Columbia, SC	4.98	1,328	15.2%	6.14	1,654	18.9%
South Dakota	Sioux Falls, SD	4.76	1,336	15.3%	6.03	1,711	19.5%
Tennessee	Nashville, TN	4.86	1,307	14.9%	5.97	1,626	18.6%
Texas	Dallas, TX	5.24	1,397	15.9%	6.57	1,768	20.2%
Utah	Salt Lake City, UT	5.24	1,437	16.4%	6.76	1,872	21.4%
Vermont	Montpelier, VT	4.21	1,183	13.5%	5.17	1,477	16.9%
Virginia	Richmond, VA	4.88	1,323	15.1%	6.06	1,667	19.0%
Washington	Seattle, WA	3.64	973	11.1%	4.47	1,218	13.9%
West Virginia	Charleston, WV	4.56	1,230	14.0%	5.58	1,522	17.4%
Wisconsin	Madison, WI	4.55	1,270	14.5%	5.58	1,582	18.1%
Wyoming	Laramie, WY	5.18	1,466	16.7%	6.62	1,906	21.8%

5.3 Pro Forma Economic Analysis

The final step in this investigation was the preparation of a pro forma economic model to evaluate the costs associated with wind and solar energy projects in each state. A 20-year levelized busbar cost was calculated for this purpose. The levelized busbar cost represents the fixed energy cost that would be equivalent to an annually escalated busbar cost over a 20-year period, or the approximate useful life of a renewable energy project. The model was based upon a generic wind or solar energy project (as applicable) and incorporated capacity factors from Sections 5.2.1 and 5.2.2, as well as expected present-day costs for these facilities, including typical capital costs, debt services expenses, tax liabilities and credits, and operating costs.

5.3.1 Pro Forma Inputs

The following estimates and economic assumptions were utilized within the pro forma financial model for this evaluation. Unless explicitly stated otherwise, it may be assumed that assumptions noted below have been equivalently applied to the wind energy scenario and both solar energy configurations. Moreover, assumptions utilized herein are intended to represent industry standard or average values and do not necessarily reflect universal conditions for all renewable energy projects.

- Operational Assumptions
  - Annual Capacity Factor — See Table 6 and Table 26
  - Commercial Operation Date — 2010
- Financing Assumptions
  - Debt Interest Rate — 7.00%
  - Debt Financing Term — 20 years
  - Capital Structure — Debt – 60%, Equity – 40%
  - Required Return on Equity — 12.00%
  - Construction Financing Fees — 0.50% of financed capital

- Permanent Financing Fees — 1.00% of financed capital
- Debt Service Reserve Funding — None

- Economic Assumptions
  - General Escalation Rate — 2.50% per annum
  - Discount Rate — 9.00%
  - Sales Tax Rate — 0.00%
  - Income Tax Rate — 40.00%
- Depreciation Assumptions
  - Straight-Line Book Depreciation Term — 20 years
  - Accelerated Depreciation Schedule — 5-Year MACRS
- Capital Cost Assumptions
  - Capital Cost Estimate (2010$) (Wind) — $2,000/kW
  - Capital Cost Estimate (2010$) (Fixed-Axis PV) — $5,230/kW
  - Capital Cost Adder for Single-Axis Tracking — 10%
- O&M Cost Assumptions
  - Fixed O&M Costs (2010$) (Wind) — $40.00/kW-year
  - Fixed O&M Costs (2010$) (Solar) — $25.00/kW-year
  - Variable O&M Costs (2010$) — $0.00/MWh
- Renewable Tax Credits
  - Production Tax Credit Value (2010$) (Wind) — $0.021/kWh
  - Production Tax Credit Escalation Rate (Wind) — 2.00%
  - Investment Tax Credit Value (Solar) — 30.00%

It should be noted that each project was assumed to be eligible for renewable tax credits. However, the wind energy scenario was modeled using the production tax credit (PTC) whereas the solar configurations were modeled using the investment tax credit (ITC). The reasons for which this variation was intentionally selected were twofold. First, solar energy projects are not eligible for the PTC whereas wind energy projects are eligible for both tax credits. Secondly, the PTC (by design) provides greater benefit to projects with high production levels whereas the ITC is a uniform credit for all projects, independent of energy generation. Thus, based on the capital cost used for the wind energy scenario ($2,000/kW) and the gross capacity factor estimates for each state, it was assumed that the wind scenario would be more appropriately modeled by utilizing the PTC instead of the ITC. Nevertheless, the overall magnitude of the tax credit would likely not be significantly different regardless of which credit was selected.

5.3.2 Pro Forma Results

Utilizing the aforementioned economic assumptions and estimated capacity factors, a 20-year levelized busbar cost was estimated for a wind energy installation, fixed-tilt solar PV installation, and single-axis tracking PV installation in each state. A summary of these results is provided in Table 7. Graphical representations of these results are included as Figure 4 and Figure 5.

The key solar energy costs presented herein represent the differential, or premium, paid relative to wind energy costs. It was assumed that some level of renewable resource integration would likely take place in most states regardless of whether solar carve-outs were implemented. Thus, it would not be prudent to use the full cost of solar energy as the basis of discussion. As such, it was compared directly to wind energy, a prevalent and cost-competitive form of renewable energy. As an example, if the 20-year levelized busbar cost for solar energy was $400/MWh in a state and the 20-year levelized busbar cost for wind energy was $100/MWh, the depicted "premium" for solar energy in that state would be $300/MWh.

The lowest differential costs are typically found in the southwestern United States and coincide with the country's preeminent solar resources. Throughout this region, the premium (relative to wind energy) paid for fixed-tilt solar PV is typically between $260/MWh and $300/MWh. Similarly, the premium (relative to wind energy) paid for single-axis tracking solar PV is typically between $190/MWh and $230/MWh.

By contrast, the highest differential costs typically occur in the northern United States and reach as high as $440/MWh (single-axis tracking solar PV) and $520/MWh (fixed-tilt solar PV).

Table 7. National Differential Analysis Results

	Wind		Fixed-Tilt PV			Single-Axis Tracking PV		
State	GCF (%)	Busbar Cost ($/MWh)	GCF (%)	Busbar Cost ($/MWh)	Solar Premium ($/MWh)	GCF (%)	Busbar Cost ($/MWh)	Solar Premium ($/MWh)
Alabama	32.2%	$100.00	15.0%	$447.90	**$347.90**	18.6%	$395.00	**$295.00**
Arizona	32.1%	$100.40	18.3%	$365.10	**$264.70**	24.0%	$305.20	**$204.80**
Arkansas	33.4%	$95.60	15.1%	$443.20	**$347.60**	19.1%	$383.20	**$287.60**
California	35.4%	$89.30	17.6%	$381.30	**$292.00**	21.9%	$334.70	**$245.40**
Colorado	38.0%	$81.90	17.7%	$377.60	**$295.70**	23.1%	$317.10	**$235.20**
Connecticut	31.4%	$102.80	13.3%	$502.40	**$399.60**	16.4%	$447.60	**$344.80**
Delaware	30.7%	$105.50	14.6%	$460.20	**$354.70**	18.2%	$401.90	**$296.40**
Florida	32.1%	$100.20	15.7%	$426.10	**$325.90**	19.6%	$373.80	**$273.60**
Georgia	33.3%	$95.90	15.2%	$440.20	**$344.30**	19.0%	$385.10	**$289.20**
Idaho	32.9%	$97.30	16.0%	$417.60	**$320.30**	21.3%	$344.60	**$247.30**
Illinois	34.9%	$90.80	14.7%	$455.90	**$365.10**	18.7%	$392.60	**$301.80**
Indiana	34.2%	$93.00	14.1%	$475.90	**$382.90**	17.5%	$418.20	**$325.20**
Iowa	40.5%	$75.60	15.4%	$434.30	**$358.70**	19.7%	$372.30	**$296.70**
Kansas	43.7%	$68.80	16.3%	$411.20	**$342.40**	20.8%	$352.90	**$284.10**
Kentucky	32.6%	$98.20	14.4%	$463.80	**$365.60**	18.1%	$405.50	**$307.30**
Louisiana	30.6%	$105.80	14.8%	$451.30	**$345.50**	18.4%	$399.20	**$293.40**
Maine	34.3%	$92.70	13.9%	$482.50	**$389.80**	17.4%	$420.60	**$327.90**
Maryland	32.9%	$97.40	14.9%	$448.60	**$351.20**	18.8%	$390.40	**$293.00**
Massachusetts	36.9%	$84.80	13.3%	$504.90	**$420.10**	16.5%	$443.60	**$358.80**
Michigan	32.7%	$98.00	13.3%	$505.40	**$407.40**	16.4%	$445.50	**$347.50**
Minnesota	39.2%	$78.80	14.5%	$460.90	**$382.10**	18.5%	$397.00	**$318.20**
Missouri	33.7%	$94.50	15.7%	$426.40	**$331.90**	19.9%	$368.10	**$273.60**
Montana	39.0%	$79.10	15.3%	$438.90	**$359.80**	19.9%	$368.30	**$289.20**
Nebraska	44.0%	$68.10	15.9%	$420.60	**$352.50**	20.1%	$363.70	**$295.60**
Nevada	32.8%	$97.70	18.7%	$358.40	**$260.70**	24.9%	$294.90	**$197.20**
New Hampshire	35.9%	$87.80	13.8%	$486.10	**$398.30**	17.3%	$423.40	**$335.60**
New Jersey	32.3%	$99.50	14.0%	$478.60	**$379.10**	17.4%	$420.90	**$321.40**
New Mexico	38.2%	$81.40	18.5%	$362.20	**$280.80**	24.2%	$302.90	**$221.50**
New York	33.1%	$96.70	14.6%	$460.20	**$363.50**	17.9%	$408.60	**$311.90**
North Carolina	33.9%	$94.10	15.0%	$445.50	**$351.40**	18.7%	$391.90	**$297.80**
North Dakota	44.2%	$67.70	15.5%	$431.10	**$363.40**	20.0%	$366.80	**$299.10**
Ohio	31.6%	$102.20	13.4%	$501.50	**$399.30**	16.6%	$442.70	**$340.50**
Oklahoma	39.5%	$78.00	16.5%	$405.50	**$327.50**	21.2%	$346.00	**$268.00**
Oregon	34.1%	$93.40	12.9%	$519.70	**$426.30**	16.5%	$443.30	**$349.90**
Pennsylvania	33.4%	$95.60	12.7%	$526.70	**$431.10**	15.6%	$469.20	**$373.60**
Rhode Island	37.4%	$83.50	13.8%	$486.50	**$403.00**	17.0%	$431.10	**$347.60**
South Carolina	31.1%	$104.00	15.2%	$441.80	**$337.80**	18.9%	$388.10	**$284.10**
South Dakota	44.1%	$67.90	15.3%	$439.20	**$371.30**	19.5%	$375.20	**$307.30**
Tennessee	33.2%	$96.20	14.9%	$448.90	**$352.70**	18.6%	$394.80	**$298.60**
Texas	39.2%	$78.80	15.9%	$420.00	**$341.20**	20.2%	$363.10	**$284.30**
Utah	32.3%	$99.40	16.4%	$408.30	**$308.90**	21.4%	$342.90	**$243.50**
Vermont	35.5%	$88.90	13.5%	$496.00	**$407.10**	16.9%	$434.60	**$345.70**
Virginia	34.3%	$92.50	15.1%	$443.50	**$351.00**	19.0%	$385.10	**$292.60**
Washington	34.3%	$92.50	11.1%	$603.00	**$510.50**	13.9%	$527.00	**$434.50**
West Virginia	35.3%	$89.50	14.0%	$477.00	**$387.50**	17.4%	$421.70	**$332.20**
Wisconsin	33.0%	$96.90	14.5%	$462.00	**$365.10**	18.1%	$405.80	**$308.90**
Wyoming	40.2%	$76.30	16.7%	$400.20	**$323.90**	21.8%	$336.80	**$260.50**

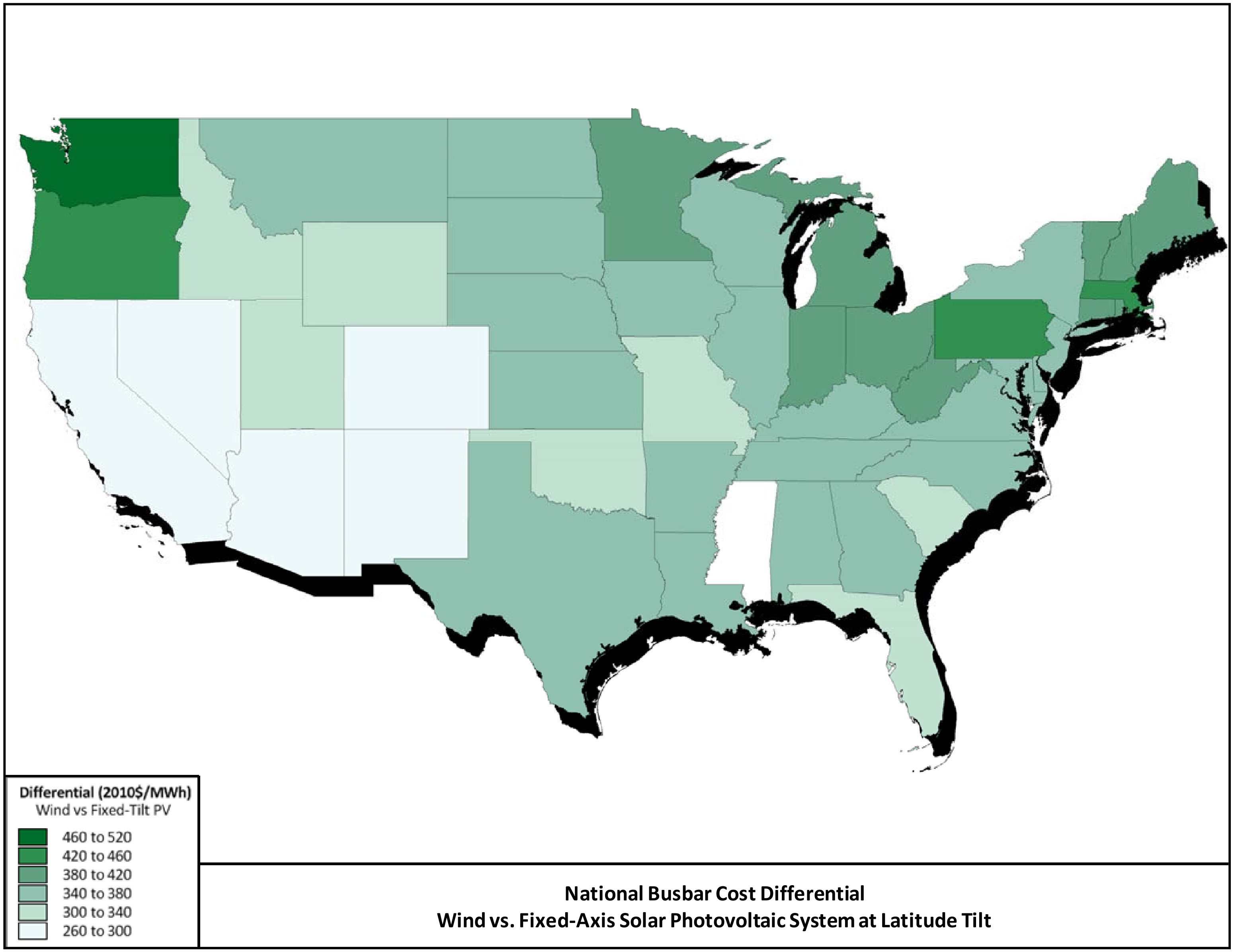

Figure 4. National Busbar Cost Differential – Wind Versus Fixed-Tilt Solar PV

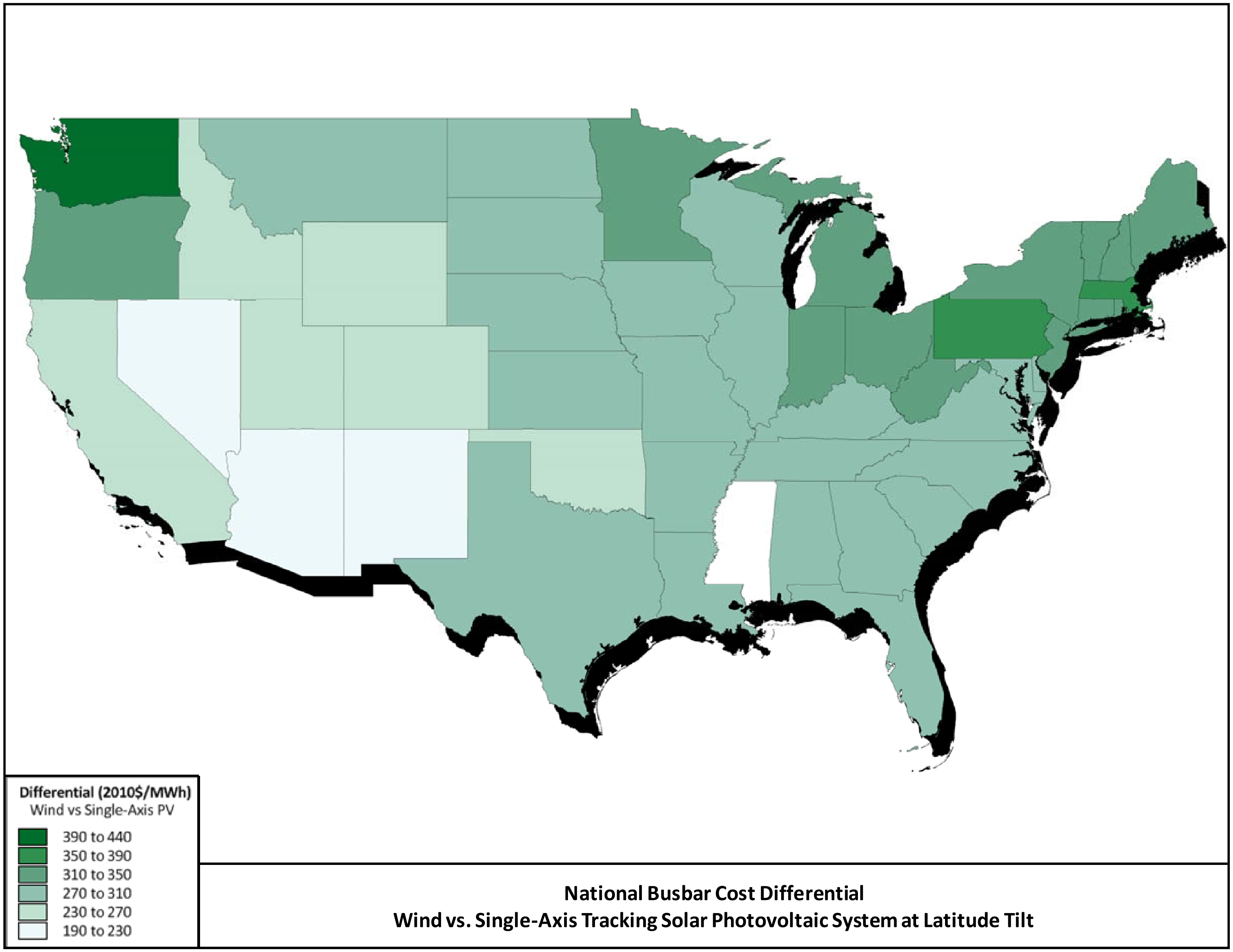

Figure 5. National Busbar Cost Differential – Wind Versus Single-Axis Tracking Solar PV

5.3.3 Busbar Cost Sensitivity Analysis

To understand the impacts of the economic inputs on the results of the busbar cost evaluation, sensitivity analyses were performed on the pro forma models for the following cases:

- Capital Cost ± 25%
- O&M Costs ± 20%
- Capacity Factor ± 10%
- Interest Rate ± 1.5 percentage points
- No Federal Tax Incentives (PTC, ITC)

The sensitivity analyses were performed for three base case scenarios:

- Wind at 35 percent capacity factor
- Fixed-tilt PV at 18 percent capacity factor
- Single-axis tracking PV at 21 percent capacity factor

The results of the sensitivity analyses are presented in the tornado diagrams in Figure 6, Figure 7, and Figure 8. A tornado diagram illustrates the range of results for each sensitivity case and its impact on the levelized busbar cost, and ranks the results from greatest impact to least impact. As expected, the sensitivity analyses indicate that the capacity factor and capital costs are by far the most significant factors affecting the economics of a wind energy or solar energy facility.

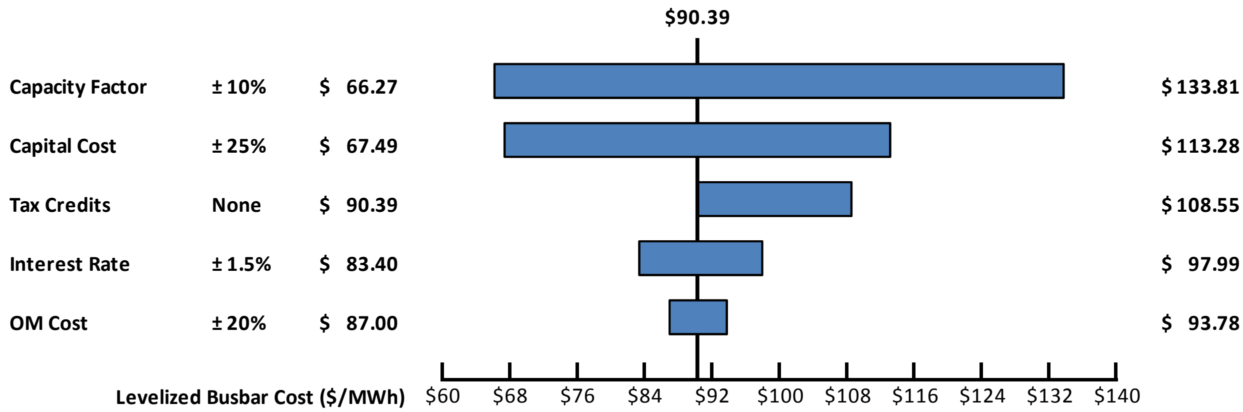

Figure 6. Sensitivity Analysis Tornado Diagram – Wind at 35% CF

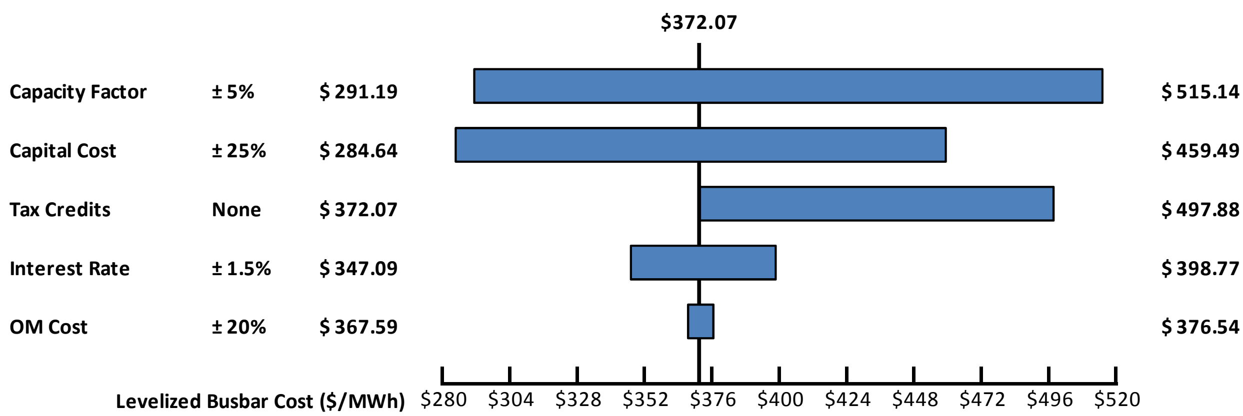

Figure 7. Sensitivity Analysis Tornado Diagram – Fixed-Tilt PV at 18% CF

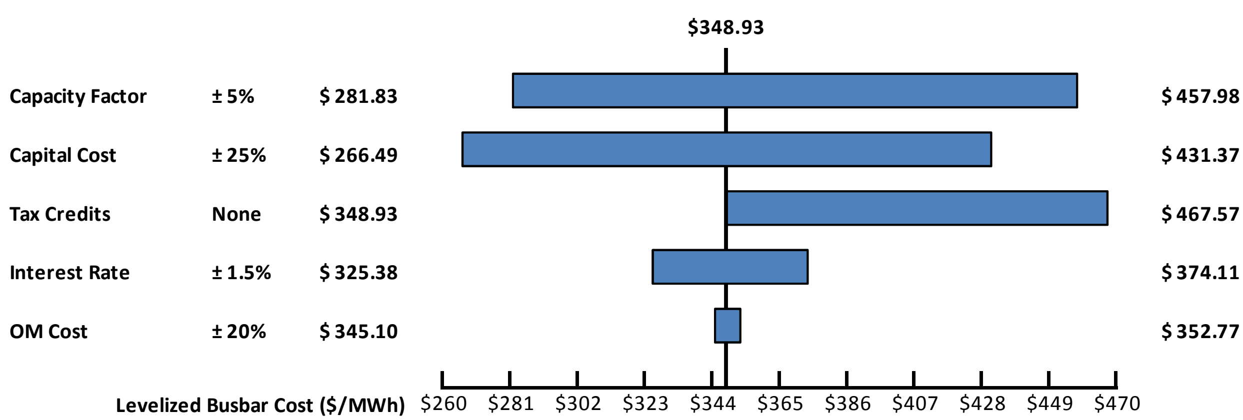

Figure 8. Sensitivity Analysis Tornado Diagram – Single-Axis Tracking PV at 21% CF

5.4 Summary and Conclusions

The following is a summary of results from this investigation, including key conclusions:

- The general performance (capacity factor) of wind and solar resources varies dramatically by state. The country's preeminent wind resources are concentrated throughout the Midwest while the best solar resources are found in the southwestern United States. This variation translates directly into the levelized cost of energy for each resource.
- Nationwide gross capacity factors for fixed-tilt solar PV resources range from a low of 11.1 percent (Washington) to a high of 18.7 percent (Nevada). The median gross capacity factor for these resources is approximately 15 percent. This is less than half of the median gross capacity factor for wind resources (34.1 percent), a significant disparity that is reflected in the levelized busbar cost for both resources.
- Both the average and median capacity factors for solar energy are *lower* in carve-out states than the national average. As a result, the average and median solar energy costs in carve-out states are *higher* than the national average. This indicates that the states with the most attractive solar resources are not the same states that are passing solar carve-out legislation.
- The most cost-competitive state for solar energy resources is Nevada ($358/MWh for fixed-tilt PV, $295/MWh for single-axis tracking PV). Conversely, the most cost-competitive state for wind energy resources is North Dakota ($68/MWh). Using these estimates, the most attractive wind resources are between three and four times less expensive than the most attractive solar resources.
- An average residential electric customer typically consumes approximately 10,000 kWh of energy in a given year and pays approximately $0.09 per kWh. Based upon these assumptions and estimates in the previous bullet, integrating only 10 percent solar energy into that customer's generation consumption would increase their average electric bill as much as 32 percent, or nearly $25 per month or $300 per year.

- On average, states utilizing solar energy are paying a premium of between $300/MWh and $359/MWh for this resource compared to wind energy, although no discernable difference exists between the delivered electricity.
- Variation in solar energy costs is far greater than in wind energy. Across the country, average wind energy costs vary by approximately 56 percent whereas solar energy costs vary between 68 percent (fixed-tilt PV) and 78 percent (single-axis tracking PV). This statistic highlights the flexibility of wind resources relative to solar and reinforces that solar energy is not cost competitive in many parts of the United States.
- Capital costs are highly influential on the levelized costs of solar energy. However, as demonstrated by the sensitivity analyses in Section 5.3.3, a significant decrease in capital costs is not as effective as a significant gain in performance.
- Solar energy costs are extremely dependent on tax credits (such as the investment tax credit) in order to be economically competitive, far more so than wind energy.

A summary of the key results from this investigation is included in Table 8.

This investigation confirmed the relative expense of solar energy and its significant premium compared to more cost-competitive resources. The high capital costs and poor efficiency of solar energy make it significantly less attractive than other sources of energy. Moreover, the states that are most aggressively pursuing solar energy legislation do not represent the optimal location for these resources. In fact, on average, solar capacity factors are lower and busbar costs are higher in carve-out states than the national average. This is not an intuitive or sensible trend.

In the following chapter, more detailed economic evaluations are undertaken to further explore the impact and viability of solar carve-outs based on actual mandates that have been implemented in various states.

Table 8. Summary of Results from Investigation Two

Description	Wind Energy	Fixed-Tilt PV	Single-Axis Tracking PV
Capacity Factors – All States			
Maximum Gross Capacity Factor	44.2%	18.7%	24.9%
Minimum Gross Capacity Factor	30.6%	11.1%	13.9%
Average Gross Capacity Factor	35.3%	15.0%	19.0%
Median Gross Capacity Factor	34.1%	15.0%	18.7%
Capacity Factors – Carve-Out States			
Maximum Gross Capacity Factor	38.2%	18.7%	24.9%
Minimum Gross Capacity Factor	30.7%	12.7%	15.6%
Average Gross Capacity Factor	33.9%	14.8%	18.7%
Median Gross Capacity Factor	33.7%	14.6%	18.2%
20-Year Levelized Busbar Costs – All States			
Maximum Busbar Cost ($/MWh)	$106	$603	$527
Minimum Busbar Cost ($/MWh)	$68	$358	$295
Average Busbar Cost ($/MWh)	$91	$450	$390
Median Busbar Cost ($/MWh)	$93	$448	$392
Average Premium Paid for Solar Over Wind ($/MWh)		$359	$300
20-Year Levelized Busbar Costs – Carve-Out States			
Maximum Busbar Cost ($/MWh)	$106	$527	$469
Minimum Busbar Cost ($/MWh)	$81	$358	$295
Average Busbar Cost ($/MWh)	$94	$460	$399
Median Busbar Cost ($/MWh)	$94	$460	$402
Average Premium Paid for Solar Over Wind ($/MWh)		$365	$305
Pro Forma Sensitivity Analyses			
Most Sensitive Input(s) to Economic Model	Capacity Factor and Capital Costs		

* * * * *

Chapter 6 - State Case Studies (Investigation 3)

Although 14 states have implemented solar energy carve-outs in their renewable portfolio standard, little consistency or homogeneity exists between these mandates. Each state has varying annual requirements for the percentage of energy that must be derived from solar resources; differing requirements exist on which entities (such as investor-owned utilities, cooperatives, municipalities, and so forth) must comply with the carve-out policies; definitions fluctuate regarding in-state versus out-of-state generation requirements; penalties for non-compliance are varied or non-existent in some states; and so forth.

Due to the complexity and diversity of existing solar carve-out legislation, providing a detailed analysis of each state's policy would be both laborious and beyond the scope of this report. Moreover, providing a standardized comparison across each state would not be achievable. As such, this investigation aims to provide a case study for three states that have implemented carve-out legislation. The chosen states – Missouri, New Jersey, and New Mexico – were judiciously selected: New Jersey's carve-out legislation is among the most aggressive in the country; New Mexico offers one of the nation's most attractive solar resources and is paired with one of the highest overall solar carve-out rates; and Missouri is relatively pedestrian in both its policies and solar resource, making it representative of a large percentage of carve-out states.

6.1 Investigation Overview

The case studies completed in this investigation were focused on two primary areas. The first area of evaluation was focused on the economic implications of solar carve-outs while the second explored the expected environmental benefits derived from these policies. A detailed overview of the methodology utilized for each of these areas of study is provided in Section 6.2. The results of the investigation for each state are provided in Section 6.4 (Missouri), Section 6.5 (New Jersey), and Section 6.6 (New Mexico).

6.2 Economic Evaluation Methodology

The objective of the economic evaluation in each state case study was to assess the potential impact on residential electric rates from implementation of a solar energy carve-out. This evaluation was completed in two steps. In the first, the PVWatts (version 2) model from NREL was utilized to estimate annual energy output from a fixed-tilt solar PV system at multiple locations throughout a state. Whereas the investigation in Section 5.0 offered a generalized national view of the statewide differential cost between solar and wind energy, this assessment was focused solely on solar resources in order to develop a range of expected busbar costs throughout the respective states. Using the derived energy estimates for each point within the state, a levelized busbar cost was calculated and this information was ultimately manipulated into a contour map, allowing the reader to visualize how the cost of energy varies with the solar resource throughout the state.

In the second part of this evaluation, the direct impact on state residential electric rates was calculated. Data pertaining to historical retail electric rates, customer usage, and retail electric sales was collected from the Energy Information Administration for each state since at least 2001. Although information from pre-2001 was available, it was intentionally omitted so that only recent trends in electric rates (including the increased integration of renewable energy) would not be diluted. Using the historical rate information, trends in the data were extracted for each respective state, such as historical escalation in rates and average customer usage.

Finally, based upon an expected cost of solar energy in each state – as derived from Chapter 5 of this report and the initial part of this evaluation as detailed above – the total impact on ratepayers was calculated. This impact is expressed both in terms of the total cost to satisfy the state's solar carve-out requirements and the estimated percentage increase in residential electric rates that will be assumed by the state's ratepayers.

It was assumed that the energy required in each state's solar carve-out would likely be required even if the carve-out did not exist. Thus, rather than use the total levelized cost of solar energy for this assessment, a differential cost was utilized so that the incremental cost of solar energy could be evaluated. Similar to the investigation presented in Chapter 5 of this report, wind energy was utilized for the differential analysis in each state case study. Not only had levelized busbar costs for wind energy already been developed for each of these states, but wind also provides a reasonable basis of comparison for solar energy. Wind is not only the most prevalent non-hydroelectric renewable resource in the United States but, much like solar, wind resources are adaptable to a variety of locations. As such, a direct comparison between these resources and utilization of wind energy costs to derive a "premium" for solar energy was deemed to be appropriate.

Finally, although the methodology used to determine the economic impacts in the state case studies is considered suitable and sound, it is not without deficiencies. The following highlights several basic assumptions (including some of the expected shortcomings) of the economic evaluation methodology utilized herein:

- Although the carve-out percentages in each state are known, it is impossible to accurately predict the manner in which utilities will satisfy the RPS requirements. For example, although the state of New Jersey requires 306 gigawatt-hours (GWh) of generation from solar energy by 2011, it is unlikely that all utilities will wait until 2011 to build that full amount; rather, most will begin adding necessary quantities of solar generation to their resource portfolio in advance of the milestone dates. However, because information pertaining to *how* each utility will satisfy RPS requirements is unavailable, this report assumes that the amount of generation necessary to maintain compliance will become operational in the year in which it is required.
- Over the past decade, installed costs for solar PV systems have dropped an average of 3.6 percent per year (Greentech Media 2009). However, as described above, it is impossible to accurately

predict the manner or haste in which utilities will satisfy RPS requirements. Thus, development of a 20-year levelized busbar cost through the investigation's pro forma economic models cannot capture these expected decreases in capital costs. Instead, all costs are presented in current (2010) dollars.

- The differential analyses performed in this report use wind energy as a competitive basis. Although wind energy offers a reasonable basis of comparison for solar energy, other sources of power may prove to be more or less economically competitive than wind energy in a given area or state. Moreover, although solar energy costs are developed for specific states based on trusted data, it is both plausible and likely that specific areas within a state may offer more cost-competitive solar energy than the generalized statewide values. Nevertheless, it is equally likely that specific areas may be less attractive than the generalized statewide values. As such, the generalized values utilized in this assessment were deemed appropriate.

A summary of the state-specific results for this portion of the investigation are provided in subsequent sections of this chapter. Tables presenting detailed calculations used to complete this evaluation, including pertinent source information (as applicable), are provided in Appendix G (Missouri), Appendix H (New Jersey), and Appendix I (New Mexico).

6.3 Environmental Evaluation Methodology

With the exception of biomass-fired facilities, renewable resources emit no pollution during operation. However, during the manufacturing process used to generate the infrastructure necessary for renewable energy facilities, varying levels of pollution are released into the atmosphere or surface water. The objective of this evaluation was to analyze and discuss the relative differences in life-cycle emissions for solar energy resources. For the same reasons noted above, the life-cycle analyses (LCA) for solar energy resources are directly compared to wind energy resources for this evaluation.

A life-cycle analysis is a cradle-to-grave quantitative assessment of the environmental impacts associated with a product. For this evaluation, the life cycle refers to the major activities undertaken in the course of the solar equipment's lifespan, from raw material sourcing, manufacturing, and use to its final disposal or reuse. The LCA allows comparisons of the environmental attributes of a competing alternative (e.g. wind) in accordance with a systematic, data-base methodology (Fthenakis, Kim and Alsema 2008).

As seen in Figure 9, life-cycle carbon dioxide emissions for solar PV systems are highly varied. These values are expressed in terms of grams of equivalent CO_2 emissions per kilowatt-hour of generation over the useful life of the solar system. Values in Figure 9 represent data extracted from two independent sources and include estimates for four types of commercially-available solar PV systems: ribbon silicon (Ribbon - Si, 11.5 percent efficient); polycrystalline silicon (Multi - Si , 13.2 percent efficient); monocrystalline silicon (Mono – Si, 14.0 percent efficient); and thin-film cadmium telluride (CdTe, 9.0 percent efficient). In each case, nearly 80 percent of the total life-cycle emissions result from production of the module.

For this evaluation, a polycrystalline silicon solar PV system (52 grams CO_2e/kWh) was assumed in order to remain consistent with other analyses performed herein.

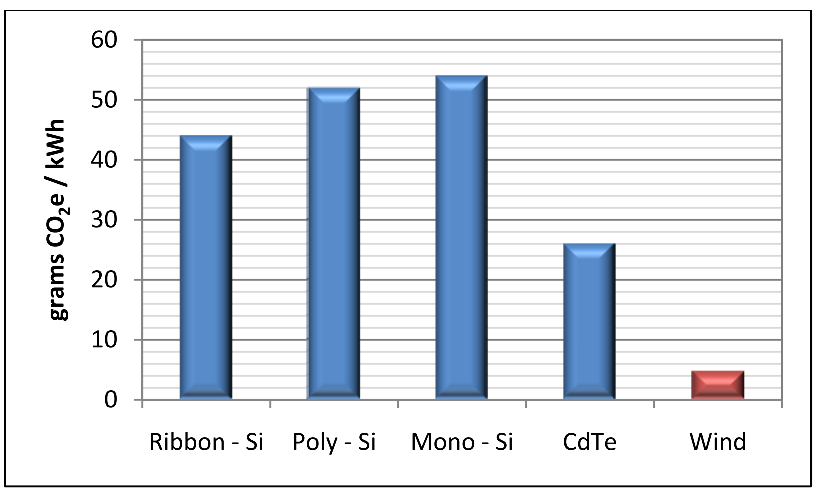

Figure 9. Life-Cycle Carbon Dioxide Emissions from Wind and Solar Energy

Sources: (Fthenakis, Kim and Alsema 2008) and (National Research Council 2010)

Also shown in Figure 9 are estimated life-cycle CO_2 emissions from wind energy resources (4.64 grams CO_2e/kWh). The LCA shows that life-cycle carbon dioxide emissions from wind energy are approximately one-fifth of those from thin-film technologies and less than a tenth of monocrystalline silicon solar PV technologies. The considerable difference in life-cycle emissions is largely driven by the poor efficiency and low net annual capacity factor for solar energy relative to wind.

As a final evaluation in each state case study, several equivalent emissions rates were calculated based on the expected amount of solar generation required to remain in compliance with solar carve-out requirements in the state RPS. Similar to the rationale described in Section 6.2 of this report, it was assumed that the energy required in each state's solar carve-out would likely be required even if the carve-out did not exist. Thus, the environmental impacts referenced from this analysis represent the impacts directly attributable to the use of solar energy to remain compliant with carve-out legislation.

A summary of the state-specific results for this portion of the investigation are provided in subsequent sections of this chapter. Tables presenting detailed calculations used to complete this evaluation, including pertinent source information (as applicable), are provided in Appendix G (Missouri), Appendix H (New Jersey), and Appendix I (New Mexico).

6.4 Case Study Results – Missouri

The following sections present an overview of the renewable portfolio standard in the state of Missouri and the results of the economic and environmental case study evaluations for this state.

6.4.1 RPS Overview

The Missouri RPS was approved by the state's Public Service Commission (PSC) on August 16, 2010, and was expected to take effect September 30, 2010 (DSIRE-b 2010); as of November 2010, this policy was still awaiting final approval by the Missouri PSC. The original legislation was enacted by voters in November 2008 through Proposition C, a ballot initiative that repealed the state's voluntary RPS and replaced it with an expanded and mandatory standard. This standard sets the following minimum benchmarks based on annual electricity sales:

Table 9. Missouri Renewable Portfolio Standard Mandates

Year	RPS (Annual %)	Solar Carve-Out (Annual %)
2011-2013	2.00%	0.04%
2014-2017	5.00%	0.10%
2018-2020	10.00%	0.20%
2021	15.00%	0.30%

Source: (DSIRE-b 2010)

Like many states, the Missouri RPS applies only to the state's four investor-owned utilities:

- Empire District Electric Company
- Kansas City Power and Light (KCP&L)
- Kansas City Power and Light Greater Missouri Operations (formerly Aquila)
- Union Electric Company (AmerenUE)

Prior to Proposition C, the Missouri legislature enacted S.B. 1181 providing an exemption from the (yet to be enacted) solar energy carve-out requirement for any utility that had achieved eligible renewable energy technology capacity of at least 15 percent of its total fossil-fired generating capacity by January 20, 2009. Empire District Electric Company has indicated it qualifies for this exemption, although formal clarification from the Missouri PSC is pending. For purposes of this study, Empire Electric District Company was assumed to be exempt from the state's solar energy carve-out requirements.

An "escape clause" exists in the Missouri RPS to prevent cost overruns associated with the addition of renewable energy to a utility's generation portfolio. More specifically, utilities may be excused from their obligation by the PSC for events beyond their control or if the cost of compliance with the standard increases retail electricity rates by more than one percent in any year. If the one percent cap is exceeded, the annual renewable energy obligation will be adjusted downward to a point where the cap is not violated (DSIRE-b 2010).

Finally, the Missouri RPS includes penalties for non-compliance. Utilities that do not meet their renewable and/or solar portfolio obligations under the RPS are subject to penalties of at least twice the market value of renewable energy credits (REC) or solar renewable energy credits (SREC). Any costs associated with non-compliance penalties may not be recovered from the utility's ratepayers.

6.4.2 Economic Impacts

Utilizing NREL's PVWatts (version 2) calculator, annual energy output from a fixed-tilt solar PV system was estimated at 150 locations throughout the state of Missouri. Using this information, the levelized busbar cost for solar energy was calculated at each location (using the same methodology as Section 5.3 of this report) and used to develop Figure 10 for this study. As represented in that figure, the cost of fixed-tilt solar PV in Missouri ranges from a low of \$399/MWh to a high of \$458/MWh. The average cost using all points considered was approximately \$430/MWh. This cost is line with the estimated value presented in Section 5.3.2 (Table 7) for Missouri (\$426/MWh), further validating the results of that investigation.

A summary of the economic impacts resulting from compliance with solar energy carve-out legislation in Missouri is presented in Table 10.

Table 10. Missouri Case Study Economic Impacts Summary

Description	Value
Total Solar Generation to Meet State RPS (MWh)	230,600
Average Blended State Rate for Solar PV (2010$/MWh)	$430
State Premium for Solar PV (2010$/MWh)	$303
Total Cost to Meet Solar Carve-Out Requirements (2010$)	$91,620,000
Total Incremental Cost to Meet Solar Carve-Out Requirements (2010$)	$69,829,000
Average Annual Impact on Retail Residential Electric Rates	0.3%
Average Annual Increase to Retail Electric Bills	$3.20

As seen in Table 10, to generate the estimated 230.6 GWh of energy necessary to remain compliant with the state's carve-out legislation, the total cost to Missouri ratepayers will be approximately $91.6 million, or approximately $69.8 million more than if the generation had been created using wind resources. These costs are based upon a state premium for solar PV of approximately $303/MWh, representing the additional cost of solar PV relative to wind energy.

The average annual impact on retail residential electric rates in Missouri from solar carve-out compliance is estimated to be approximately 0.3 percent, or a net gain of roughly $3.20 to a typical ratepayer's annual electric bill.

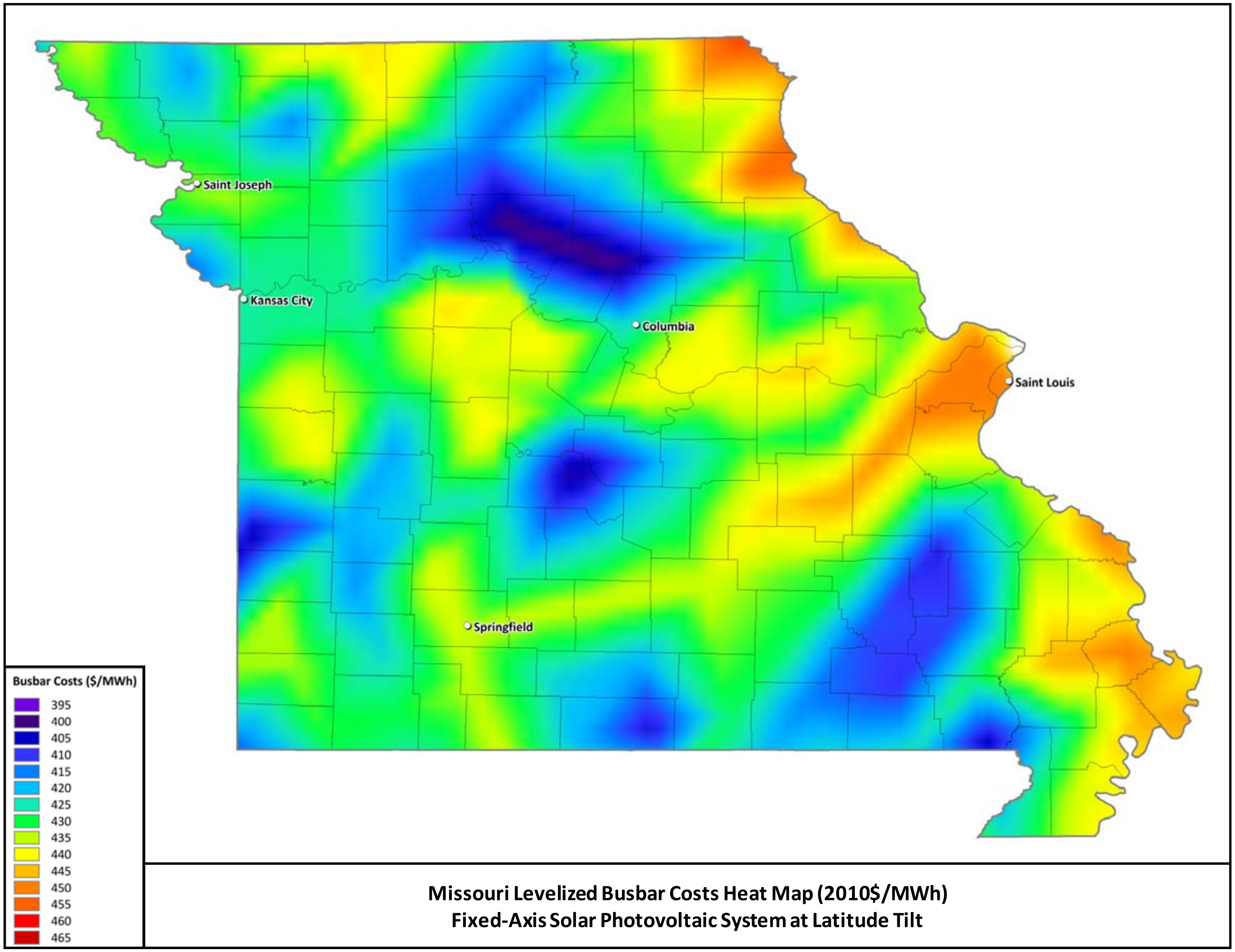

Figure 10. Missouri Levelized Busbar Costs for Fixed-Axis Solar PV at Latitude Tilt

6.4.3 Environmental Impacts

A summary of the aggregate environmental impacts resulting from compliance with solar energy carve-out legislation in Missouri is presented in Table 11.

Table 11. Missouri Case Study Environmental Impacts Summary

LCA Emissions from Satisfying State Solar Carve-Out	Value
Differential Carbon Dioxide Emissions (tons)*	12,040
Equivalent Quantity of Combusted Coal (tons)	6,960
Equivalent Quantity of Combusted Gasoline (gallons)	1,241,000

**compared to equivalent wind generation*

To generate the estimated 230.6 GWh of energy necessary to remain compliant with the state's carve-out legislation, an additional 12,040 tons of carbon dioxide will be emitted into the atmosphere due to using solar energy (and its higher associated life-cycle emissions) instead of wind energy. This is equivalent to burning nearly 7,000 tons of coal or more than 1.2 million gallons of gasoline. Note that these emission rates are based upon a life-cycle assessment for solar and wind resources and reflect activities undertaken during the resource's life cycle (including raw material sourcing, manufacturing, and final disposal); these rates do not reflect emissions from the actual operation of these resources.

6.4.4 Summary and Conclusions

A summary of notable observations from the results of this state case study is provided below:

- The levelized cost of solar energy in Missouri is nearly \$300/MWh higher than wind energy. This represents a significant premium to pay for this resource relative to more cost-competitive alternatives.
- The total cost of compliance with the Missouri solar energy carve-out is estimated at \$91.6 million, or approximately \$69.8 million more than if the energy had been generated using wind resources. Missouri ratepayers will be responsible for paying this premium to support the utilization of solar energy in their state.

- Despite the high total cost of compliance, the average annual increase to retail residential electric bills is estimated at only 0.3 percent. This amounts to an annual increase of roughly $3.20 for each customer. Thus, measurable economic impacts on individual ratepayers resulting from solar carve-out legislation are expected to be limited.
- More than 12,000 additional tons of carbon dioxide will be released into the atmosphere due to the solar energy carve-out in Missouri's RPS.

6.5 Case Study Results – New Jersey

The following sections present an overview of the renewable portfolio standard in the state of New Jersey and the results of the economic and environmental case study evaluations for this state.

6.5.1 RPS Overview

The New Jersey RPS was originally adopted in 1999 and was most recently modified in August 2010. The mandate applies to all retail electric sales in the state and includes the nation's most aggressive solar energy carve-out at more than 5,300 GWh of solar energy required for compliance. The following schedule represents current New Jersey RPS requirements (note that the term "energy year" in Table 12 refers to a period from June through May and references the year in which an energy year ends):

Table 12. New Jersey Renewable Portfolio Standard Mandates

Energy Year	RPS (Annual %)	Solar Carve-Out (GWh)
2005	3.25%	
2006	3.50%	
2007	4.57%	
2008	5.51%	
2009	6.50%	
2010	7.41%	
2011	8.30%	306
2012	9.21%	442
2013	10.14%	596
2014	11.10%	772
2015	12.07%	965
2016	13.08%	1,150
2017	14.10%	1,357
2018	16.16%	1,591
2019	18.25%	1,858
2020	20.37%	2,164
2021	22.50%	2,518
2022		2,928
2023		3,433
2024		3,989
2025		4,610
2026		5,316

Source: (DSIRE-c 2010)

An "escape clause" exists in the New Jersey RPS to prevent cost overruns associated with compliance. More specifically, the Board of Public Utilities (BPU) is required to freeze the solar energy requirement if it determines that the total cost of solar incentives during a reporting year exceed two percent of the total retail price of electricity during that reporting year. The "total cost of solar incentives" is defined to include the costs associated with the state solar rebate program, SREC purchases, solar alternative compliance payments, and several other forms of assistance. The annual increases defined by the solar compliance schedule will resume when the BPU determines that the total cost of solar incentives did not exceed two percent during a reporting year. Freezing the requirements therefore has the effect of maintaining the percentage requirements, but pushing them back by one or more years (DSIRE-c 2010).

Finally, the New Jersey RPS includes among the most severe penalties in the country for non-compliance. The BPU initially set SACP penalties at $300 per MWh in 2004 and these remained unchanged for several years. However, beginning in 2007, the BPU established the following eight-year SACP schedule:

- EY2009: $711 per MWh
- EY2010: $693 per MWh
- EY2011: $675 per MWh
- EY2012: $658 per MWh
- EY2013: $641 per MWh
- EY2014: $625 per MWh
- EY2015: $609 per MWh
- EY2016: $594 per MWh

This penalty schedule represents an annual decrease of approximately 2.5 percent.

6.5.2 Economic Impacts Analysis

Utilizing NREL's PVWatts (version 2) calculator, annual energy output from a fixed-tilt solar PV system was estimated at 38 locations throughout the state of New Jersey. Using this information, the levelized busbar cost for solar energy was calculated at each location (using the same methodology as Section 5.3 of this report) and used to develop Figure 11. As represented in that figure, the cost of fixed-tilt solar PV in New Jersey ranges from a low of $431/MWh to a high of $521/MWh. The average cost using all points considered was approximately $472/MWh. This cost is line with the estimated value presented in Section 5.3.2 (Table 7) for New Jersey ($478/MWh), further validating the results of that investigation.

A summary of the economic impacts resulting from compliance with solar energy carve-out legislation in New Jersey is presented in Table 13.

Table 13. New Jersey Case Study Economic Impacts Summary

Description	Value
Total Solar Generation to Meet State RPS (MWh)	5,316,000
Average Blended State Rate for Solar PV (2010$/MWh)	$472
State Premium for Solar PV (2010$/MWh)	$350
Total Cost to Meet Solar Carve-Out Requirements (2010$)	$2,390,885,000
Total Incremental Cost to Meet Solar Carve-Out Requirements (2010$)	$1,862,150,000
Average Annual Impact on Retail Residential Electric Rates	1.1%
Average Annual Increase to Retail Electric Bills	$14.60

As seen in Table 13, to generate the estimated 5,316 GWh of energy necessary to remain compliant with the state's carve-out legislation, the total cost to New Jersey ratepayers will be approximately $2.4 billion, or approximately $1.9 billion more than if the generation had been created using wind resources. These costs are based upon a state premium for solar PV of approximately $350/MWh, representing the additional cost of solar PV relative to wind energy.

The average annual impact on retail residential electric rates in New Jersey from solar carve-out compliance is estimated to be approximately 1.1 percent, or a net gain of roughly $14.60 to a typical ratepayer's annual electric bill.

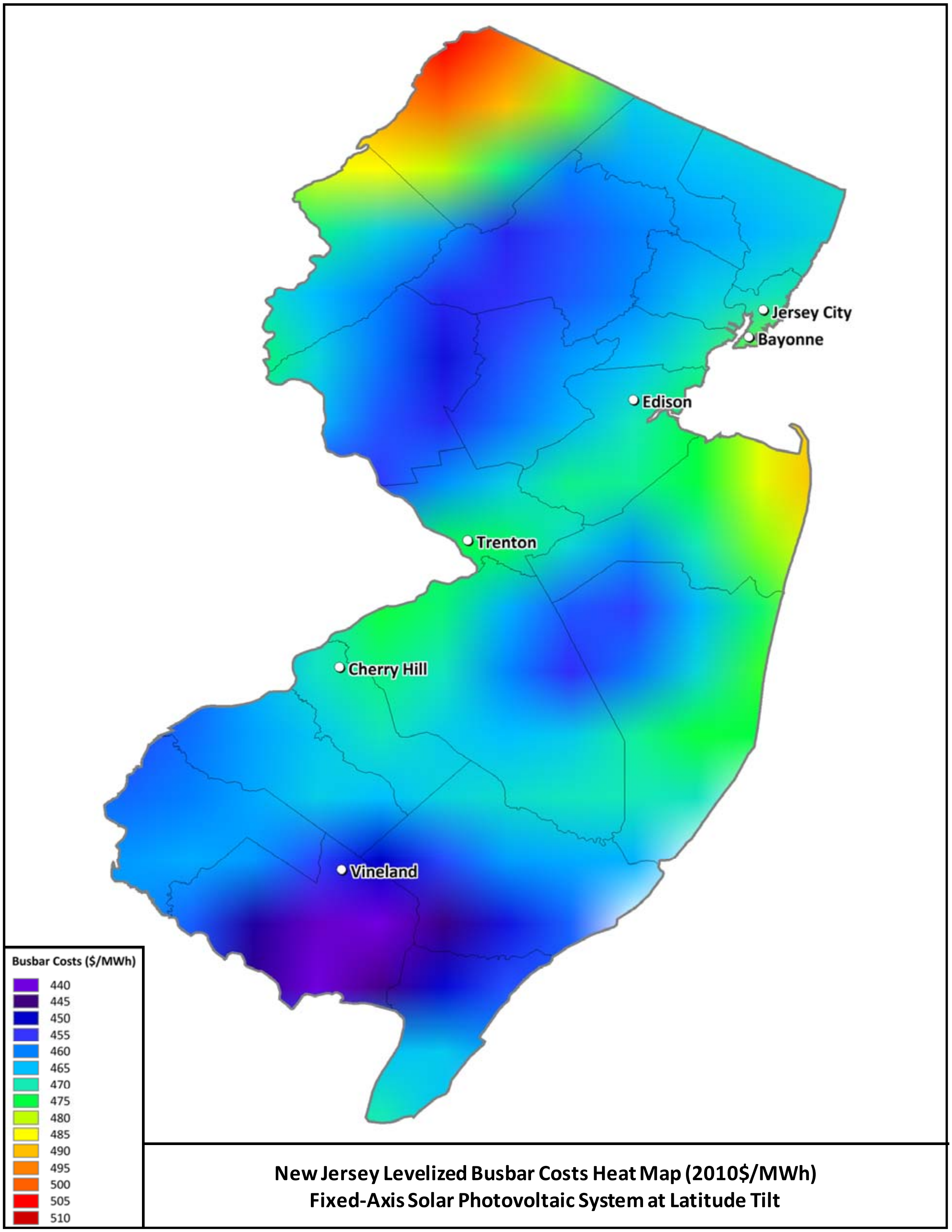

Figure 11. New Jersey Levelized Busbar Costs for Fixed-Axis Solar PV at Latitude Tilt

6.5.3 Environmental Impacts

A summary of the aggregate environmental impacts resulting from compliance with solar energy carve-out legislation in New Jersey is presented in Table 14.

Table 14. New Jersey Case Study Environmental Impacts Summary

LCA Emissions from Satisfying State Solar Carve-Out	Value
Differential Carbon Dioxide Emissions (tons)*	277,500
Equivalent Quantity of Combusted Coal (tons)	160,400
Equivalent Quantity of Combusted Gasoline (gallons)	28,611,000

**compared to equivalent wind generation*

To generate the estimated 5,316 GWh of energy necessary to remain compliant with the state's carve-out legislation, an additional 277,500 tons of carbon dioxide will be emitted into the atmosphere due to using solar energy (and its higher associated life-cycle emissions) instead of wind energy. This is equivalent to burning nearly 160,000 tons of coal or more than 28.6 million gallons of gasoline. Note that these emission rates are based upon a life-cycle assessment for solar and wind resources and reflect activities undertaken during the resource's life cycle (including raw material sourcing, manufacturing, and final disposal); these rates do not reflect emissions from the actual operation of these resources.

6.5.4 Summary and Conclusions

A summary of notable observations from the results of this state case study is provided below:

- The levelized cost of solar energy in New Jersey is nearly \$350/MWh higher than wind energy. This represents a significant premium to pay for this resource relative to more cost-competitive alternatives.
- The total cost of compliance with the New Jersey solar energy carve-out is estimated at \$2.4 billion, or approximately \$1.9 billion more than if the energy had been generated using wind resources. New Jersey ratepayers will be responsible for paying this premium to support the utilization of solar energy in their state.

- Despite the high total cost of compliance, the average annual increase to retail residential electric bills is estimated at only 1.1 percent. This amounts to an annual increase of roughly $14.60 for each customer, or slightly more than $1 per month. Thus, measurable economic impacts on individual ratepayers resulting from solar carve-out legislation are expected to be limited.
- More than 277,000 additional tons of carbon dioxide will be released into the atmosphere due to the solar energy carve-out in New Jersey's RPS. This is equivalent to burning more than 28.6 million gallons of gasoline.

6.6 Case Study Results – New Mexico

The following sections present an overview of the renewable portfolio standard in the state of New Mexico and the results of the economic and environmental case study evaluations for this state.

6.6.1 RPS Overview

The New Mexico RPS was enacted through SB 418 in March 2007, directing investor-owned utilities to generate 20 percent of total retail electric sales from renewable energy resources by 2020. The 2020 target in New Mexico must be met through a "fully diversified renewable energy portfolio", which is defined as a minimum of 20 percent solar power; 20 percent wind power; and 10 percent power from biomass, geothermal energy, and other renewables (DSIRE-d 2010). The following minimum benchmarks are set for New Mexico's investor-owned utilities:

Table 15. New Mexico Renewable Portfolio Standard Mandates

Year	RPS (Annual %)	Solar Carve-Out (Annual %)
2011-2014	10.0%	2.0%
2015-2019	15.0%	3.0%
2020	20.0%	4.0%

Source: (DSIRE-d 2010)

Only three investor-owned utilities are subject to the New Mexico RPS:

- El Paso Electric Company
- Public Service Company of New Mexico
- Southwestern Public Service Company

The New Mexico bill that created the state RPS also established a minimum standard for rural electric cooperatives. However, because these entities are not subject to the solar energy carve-out, they were excluded from further analyses in this report.

An “escape clause” exists in the New Mexico RPS to prevent cost overruns associated with the addition of renewable energy resources necessary to remain compliant with the standard. More specifically, a “reasonable cost threshold” of two percent will be in place starting in 2011. This cost increases by 0.25 percent annually until 2015, at which time it will be three percent. In any given year, if the cost to procure renewable energy is greater than the reasonable cost threshold, the utility will not be required to incur that cost (DSIRE-d 2010).

Finally, the New Mexico RPS currently contains no explicit penalties relating to non-compliance.

6.6.2 Economic Impacts Analysis

Utilizing NREL’s PVWatts (version 2) calculator, annual energy output from a fixed-tilt solar PV system was estimated at 231 locations throughout the state of New Mexico. Using this information, the levelized busbar cost for solar energy was calculated at each location (using the same methodology as Section 5.3 of this report) and used to develop Figure 12. As represented in that figure, the cost of fixed-tilt solar PV in New Mexico ranges from a low of $325/MWh to a high of $381/MWh. The average cost using all points considered was approximately $355/MWh. This cost is line with the estimated value presented in Section 5.3.2 (Table 7) for New Mexico ($362/MWh), further validating the results of that investigation.

A summary of the economic impacts resulting from compliance with solar energy carve-out legislation in New Mexico is presented in Table 16.

Table 16. New Mexico Case Study Economic Impacts Summary

Description	Value
Total Solar Generation to Meet State RPS (MWh)	805,426
Average Blended State Rate for Solar PV (2010$/MWh)	$355
State Premium for Solar PV (2010$/MWh)	$251
Total Cost to Meet Solar Carve-Out Requirements (2010$)	$267,851,000
Total Incremental Cost to Meet Solar Carve-Out Requirements (2010$)	$202,292,000
Average Annual Impact on Retail Residential Electric Rates	3.0%
Average Annual Increase to Retail Electric Bills	$25.40

As seen in Table 16, to generate the estimated 805.4 GWh of energy necessary to remain compliant with the state's carve-out legislation, the total cost to New Mexico ratepayers will be approximately $267.9 million, or approximately $202.3 million more than if the generation had been created using wind resources. These costs are based upon a state premium for solar PV of approximately $251/MWh, representing the additional cost of solar PV relative to wind energy.

The average annual impact on retail residential electric rates in New Mexico from solar carve-out compliance is estimated to be approximately 3.0 percent, or a net gain of roughly $25.40 to a typical ratepayer's annual electric bill.

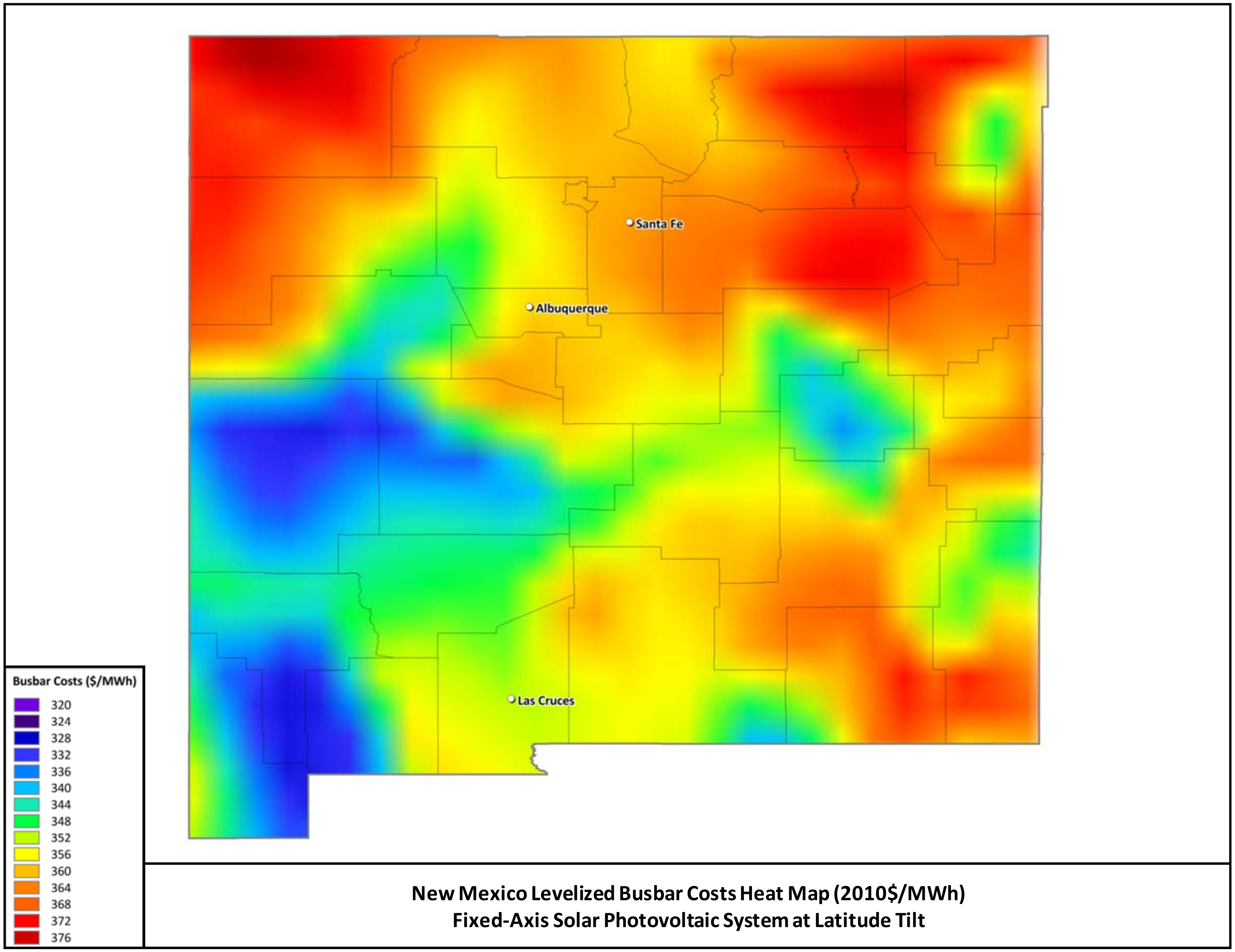

Figure 12. New Mexico Levelized Busbar Costs for Fixed-Axis Solar PV at Latitude Tilt

6.6.3 Environmental Impacts

A summary of the aggregate environmental impacts resulting from compliance with solar energy carve-out legislation in New Mexico is presented in Table 17.

Table 17. New Mexico Case Study Environmental Impacts Summary

LCA Emissions from Satisfying State Solar Carve-Out	Value
Differential Carbon Dioxide Emissions (tons)*	42,000
Equivalent Quantity of Combusted Coal (tons)	24,300
Equivalent Quantity of Combusted Gasoline (gallons)	4,335,000

**compared to equivalent wind generation*

To generate the estimated 805.4 GWh of energy necessary to remain compliant with the state's carve-out legislation, an additional 42,000 tons of carbon dioxide will be emitted into the atmosphere due to using solar energy (and its higher associated life-cycle emissions) instead of wind energy. This is equivalent to burning nearly 24,000 tons of coal or more than 4.3 million gallons of gasoline. Note that these emission rates are based upon a life-cycle assessment for solar and wind resources and reflect activities undertaken during the resource's life cycle (including raw material sourcing, manufacturing, and final disposal); these rates do not reflect emissions from the actual operation of these resources.

6.6.4 Summary and Conclusions

A summary of notable observations from the results of this state case study is provided below:

- The levelized cost of solar energy in New Mexico is nearly $251/MWh higher than wind energy. This represents a significant premium to pay for this resource relative to more cost-competitive alternatives.
- The total cost of compliance with the New Mexico solar energy carve-out is estimated at $267.9 million, or approximately $202.3 million more than if the energy had been generated using wind resources. New Mexico ratepayers will be responsible for paying this premium to support the utilization of solar energy in their state.

- Despite the high total cost of compliance, the average annual increase to retail residential electric bills is estimated at only 3.0 percent. Although this is nearly triple the rate in any other state considered, this amounts to an annual increase of roughly $25.40 for each customer, or approximately $2 per month. Thus, measurable economic impacts on individual ratepayers resulting from solar carve-out legislation are expected to be limited.
- More than 42,000 additional tons of carbon dioxide will be released into the atmosphere due to the solar energy carve-out in New Mexico's RPS.

6.7 State Case Study Conclusions

The economic impact of complying with solar carve-out legislation was examined in three states. The aggregate impact of this legislation in these states was considerable, totaling nearly $2.8 billion to achieve compliance. This is nearly $2.1 billion greater than the expected cost of using wind energy to produce the same amount of energy. Moreover, because electric utilities in these states are permitted to recover these expenses to remain compliant with carve-out mandates, ratepayers will ultimately be responsible for paying these costs to support the utilization of solar energy in their state. During a time of significant economic tribulation in the United States, forcing solar energy into a generation mix in which it is not economically competitive is not prudent or fair to ratepayers.

Despite the high total cost of compliance, the average electric rate increase expected for residents of these states is modest. New Jersey, with a differential cost of $1.9 billion estimated to satisfy these mandates, is expected to see an average annual increase to retail electric rates of only 1.1 percent. This amounts to an annual increase of roughly $14.60 for each customer, illustrating the large population that these costs may be spread among and the high electric rates currently in place in that state. By contrast, New Mexico is expected to pay up to $202.3 million to remain in compliance with carve-out legislation. However, because this state's population and electric rates are much smaller, the average annual increase in residential electric rates is nearly three percent, or approximately three times higher than New Jersey despite an aggregate cost of compliance that is one-tenth the size.

Finally, the environmental impacts of using solar resources were considered in this investigation. Despite producing no emissions during operation, solar energy produces nearly 12 times more carbon dioxide over its lifetime than wind energy, primarily as a result of differences in manufacturing processes. Based on the three states considered in this analysis, achieving compliance with carve-out legislation will result in more than 331,000 additional tons of carbon dioxide being released into the atmosphere despite no tangible differences in the electricity that is produced.

This investigation identified numerous economic and environmental hurdles associated with solar carve-out legislation. In the following chapter, a summary of all conclusions derived from this report is presented.

* * * * *

Chapter 7 - Conclusions

Renewable portfolio standards are resulting in significant increases in the level of integration of renewable energy in the United States. However, solar resources have yet to realize the same prosperity as other forms of renewable energy. In fact, at only 0.2 percent of all U.S. electricity production in 2009, solar energy represented the lowest-producing resource in the country. Moreover, solar resources are not expected to play a prominent role in the long-term energy mix of the United States. By 2035, barely one percent of all electric capacity in this country is expected to be comprised of solar resources.

Several factors hinder the potential for wide-scale and long-term utilization of solar energy. First, energy from solar-powered resources is among the most expensive forms of electricity in the country. Solar PV generally has a nonsubsidized cost of nearly 10 times that of the cost of the country's current electric generation mix and between three and five times the cost of other renewable generation options. Because there is no tangible difference in the electricity produced from solar resources and other energy generation alternatives, it is difficult to economically justify the widespread use of solar.

Solar energy systems are also accompanied by poor efficiency. Although this is likely to improve over time as new technologies continue to emerge, the location of the country's best solar resources will not. The most attractive solar resources in the United States are concentrated in the southwestern part of the country, much like geothermal resources are commonly restricted to the western United States and the greatest wind resources are typically found in the Midwest. And, while most renewable energy alternatives can generally be developed in any state, the effectiveness of those alternatives – both in terms of economics and performance – will vary dramatically with location. Based on the extremely limited regions of superior solar insolation in the United States and the limited efficiency of solar technology even under ideal circumstances, the anecdotal "floor" for solar energy costs will likely never fall below that of many other renewable energy alternatives unless significant technological breakthroughs in solar panel designs occur.

The poor efficiency of solar technologies and the limited availability of regions of high solar insolation in the United States combine to result in inherently low capacity factors from solar energy systems. Solar capacity factors are often half of those observed for wind power facilities, a third of the capacity factor of many hydroelectric facilities, and barely a quarter of a geothermal facility's typical capacity factor. Because solar energy systems produce a significantly lower percentage of energy relative to their potential output, solar facilities must be substantially overbuilt relative to other renewable resources to produce the same amount of generation. And, when solar carve-outs are incorporated into renewable portfolio standards, the state's ratepayers must then heavily subsidize the most expensive and inefficient renewable alternative.

Despite the numerous shortcomings of solar energy, it does feature many advantages. Perhaps the most important benefit of solar energy is the time at which it is produced. Despite a low total level of power output, it occurs exclusively during daytime hours, aligning very well with peak customer usage. By contrast, a wind energy system may generate twice the electricity of an equivalently-sized solar system, yet most of its output is seen during nighttime hours and winter months, or when customer demand is often at its lowest. Due to the worldwide lack of cost-effective forms of energy storage, the ability of solar generation to match customer demand is a resounding benefit for solar energy relative to any other form of renewable generation.

Another notable benefit of solar energy is its functional use in the form of distributed generation. Most forms of alternative electric generation are restricted to remote areas where populations (and demand) are sparse. Electricity must then travel over many miles of high-voltage transmission lines to reach the areas of high demand. By contrast, solar PV can be sited on rooftops and other confined locations directly within urbanized areas. In the future as renewable resources become even more engrained in the United States' generation portfolio, the flexible nature of solar energy may prove to be a significant benefit in terms of alleviating concerns relating to electric transmission congestion.

Like solar, renewable energy alternatives in general offer many tangible benefits that deserve consideration. With no fuel costs and minimal variable expenses, these resources will only become increasingly cost-effective as capital costs continue to fall over time. Moreover, regardless of one's views on climate change, it is difficult to argue the environmental advantages associated with these resources relative to the combustion of fossil fuels.

Numerous states have already begun their pursuit for the benefits associated with renewable energy. However, many of these states have created an artificial distinction in their RPS that solar resources are better than other forms of renewable energy, adding carve-out provisions to specifically advance the use of solar energy. These states have their own motivations for implementing these policies, such as diversification of their generation portfolio or in-state job creation. Nevertheless, solar carve-outs are coming at a great economic and environmental cost. As demonstrated by this study, the direct impact of solar carve-outs will be billions of dollars in added costs and the release of thousands of tons of carbon dioxide.

The underlying objectives of both renewable portfolio standards and solar carve-outs have merit. However, by specifying a winning technology, state legislators are essentially approving a mandatory, non-debatable fee on customers to support solar energy. These state governments would be better served to instead outline the goals of their renewable energy policy – reduce pollution and greenhouse gas emissions, improve power quality, maintain electric supply reliability, and control costs – and provide incentives to reach them. No current technology, including solar, satisfies all of these goals. Thus, legislators must allow for tradeoffs and leave the means of realizing the goals to the market.

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Chapter 8 - Suggestions for Additional Work

During the course of this study, numerous areas of additional study beyond the scope of this report were identified. The following list is presented for any reader interested in opportunities for further investigation into the subject of solar energy carve-outs.

8.1 Declining Capital Cost Evaluation

Over the past decade, installed costs for solar PV systems have fallen an average of 3.6 percent per year (Greentech Media 2009). Additional research may attempt to quantify the expected annual decrease in system capital costs and examine how this impacts the analyses performed in this report. More specifically, rather than developing nominal levelized busbar cost estimates, further evaluation may attempt to capture the real annual costs associated with solar energy carve-outs and assess any differences that result.

8.2 Green Jobs

As discussed in Section 2.4.3 of this report, a common benefit often associated with a solar carve-out is the creation of jobs. Many governors have embraced opportunities to foster long-term economic development in their states. Additional research may focus on the tangible benefits of this in-state development and its ability to offset to direct costs to ratepayers from utilizing solar energy. Moreover, the research may uncover quantifiable differences in the number of green jobs created from solar energy relative to other forms of renewable energy.

8.3 Time of Day Usage

Perhaps the most significant benefit of solar energy is the time at which it is produced. Solar system output occurs during daytime hours and aligns well with peak customer usage. Additional research may focus on the qualitative benefits of this characteristic of solar energy. Moreover, retail energy prices are typically highest during the day. Because wind resources typically produce their peak output during offpeak (evening and nighttime) hours when energy prices are at their lowest, it may be interesting to assess the quantitative economic benefits of solar energy simply from a time of use perspective.

8.4 Location of Solar Energy Manufacturing Facilities

The first investigation in this report attempted to characterize carve-out states. As an additional means of characterization, the reader may attempt to establish the location of major solar manufacturing facilities throughout the United States and correlate their presence with the passage of solar energy carve-outs. The location of the various pro-solar organizations (e.g. Solar Energy Industries Association, American Solar Energy Society, etc.) and their satellite locations may also lend merit to this analysis.

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Appendix A

Glossary of Terms

Throughout this report, references are made to a number of important terms. To aid the reader and to ensure a proper and clear understanding of these terms, the following paragraphs offer a brief overview of several terms contained herein.

Alternating Current

An *alternating current* (AC) is an electric current that reverses its direction at regularly recurring intervals. Concentrating solar power resources typically produce AC electricity. Solar photovoltaic resources typically produce direct-current electricity.

Capacity

The *capacity*, or power, of a resource is the rate at which is performs work or converts energy. Power may be measured at any point in time and is commonly denoted in Watts, defined as one Joule per second (J/s). Thus, a facility with a capacity of 10 megawatts (MW) would produce 10,000,000 Joules of energy every second.

Capacity Factor

The ratio of electrical energy produced by a generating unit for a period of time compared to the energy that could have been produced at full, continuous power operation during the same period is represented by the unit's *capacity factor* (EIA-d 2010). As an example, a 10-megawatt facility can theoretically produce up to 87,600 MWh of energy annually (assuming 8,760 hours in year). However, due to facility maintenance, weather-related impacts, and various other influences, the facility may only generate 74,460 MWh of energy during the same period. As such, the facility would have an 85 percent capacity factor.

Carbon Tax

A *carbon tax* is an environmental tax on emissions of carbon dioxide. No formal carbon tax has been implemented in the United States. However, several energy and climate bills have proposed a carbon tax in order to curb greenhouse gas emissions. A carbon tax is typically referenced in terms of dollars per ton of CO_2 emissions.

Concentrating Solar Power

A *concentrating solar power* (CSP) system is a solar energy conversion system characterized by the optical concentration of solar rays through an arrangement of mirrors to generate a high temperature working fluid (such as water). Examples of CSP systems include a solar trough, solar power tower, and solar dish (EIA-d 2010).

Direct Current

Direct current (DC) electricity represents a continuous movement of electrons in a single direction, from an area of negative charge to an area of positive charge. Solar photovoltaic (PV) cells generate direct current electricity. When using solar PV cells for commercial applications or when outputting electricity to the regional electric transmission grid, it must be converted to alternating current using an inverter.

Distributed Generation

Distributed generation (DG) is a reference to a generator that is located close to the particular load that it is intended to serve.

Direct Normal Irradiance

Direct Normal Irradiance (DNI) is the amount of solar radiation received per unit area by a surface that is always held perpendicular (normal) to the rays that come in a straight line from the direct of the sun at its current position in the sky (3TIER 2010).

Feed-In Tariff

A *feed-in tariff* (FIT) is a policy measure used to encourage the use of renewable energy sources. It represents a minimum rate that utilities must pay generators for energy.

Generation

The amount of *generation* from a facility represents the energy it produces over a certain period of time. Over the course of an hour, a facility with a capacity of 10 MW would produce up to 10 megawatt-hours (MWh) of energy.

Greenhouse Gases

Greenhouse gases (GHG) are those gases, such as water vapor, carbon dioxide, nitrous oxide, methane, hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride, that are transparent to solar radiation but opaque to long-wave radiation, thus preventing long-wave radiant energy from leaving Earth's atmosphere (EIA-d 2010).

Life-Cycle Analysis

A *life-cycle analysis* (LCA) is a cradle-to-grave quantitative assessment of the environmental impacts associated with a product.

Photovoltaic

A *photovoltaic* (PV) cell is an electronic device consisting of layers of semiconductor materials fabricated to form a junction and electrical contacts and being capable of converting incident light into direct current electricity (EIA-d 2010).

Renewable Portfolio Standard

A *renewable portfolio standard* (RPS) is a mandate requiring utilities and retail electric providers to produce a specified percentage of their electricity from approved renewable energy sources.

Solar Carve-Out

A *solar carve-out*, also referred to as a set-aside, mandates that a certain percentage of electricity supply must be provided by approved solar resources. Many states also specify distributed generation resources as part of their carve-out.

Solar Insolation

Solar insolation is a measure of the sun’s radiation that is received on a given surface over a given time.

Solar Multiplier

A *multiplier* may be used in lieu of or in addition to a solar carve-out. This incentive is used to give more credit to solar electricity than other forms of generation for satisfying requirements in a renewable portfolio standard.

Appendix B

Conversions and Equivalence List

The following conversion factors were assumed for this report.

Measures of Power	1 Watt (W)	=	1 Joule per second (J/s)
	1 kilowatt (kW)	=	1,000 Watts
	1 megawatt (MW)	=	1,000 kilowatts
	1 gigawatt (GW)	=	1,000 megawatts
	1 terawatt (TW)	=	1,000 gigawatts
Measures of Energy	1 kilowatt-hour (kWh)	=	3,412 British thermal units (Btu)
	1 kilowatt-hour (kWh)	=	1,000 Watt-hours
	1 megawatt-hour (MWh)	=	1,000 kilowatt-hours
	1 gigawatt-hour (GWh)	=	1,000 megawatt-hours
	1 terawatt-hour (TWh)	=	1,000 gigawatt-hours
Measures of Finance	1 Euro (€)	=	1.2929 U.S. dollars (effective 7/23/2010)

Appendix C

Solar Insolation Maps

Solar insolation is a measure of the sun's radiation that is received on a given surface over a given time. Two distinct types of solar insolation are typically measured. For flat-plate collectors at a fixed tilt, total radiation is typically of most interest. This quantity includes both direct and indirect (diffuse) radiation on a surface. Figure 13 shows the average annual solar radiation throughout the United States for solar PV resources.

Figure 14 shows the direct normal irradiance (DNI) in the United States. DNI is the amount of solar radiation received per unit area by a surface that is always held perpendicular (normal) to the rays that come in a straight line from the direct of the sun at its current position in the sky. The DNI is most relevant to PV systems that track the sun or CSP systems (3TIER 2010).

Figure 15 presents solar radiation throughout the United States as a direct comparison to Germany. This information is presented to demonstrate a direct comparison to Germany, a world-leader in solar PV installations.

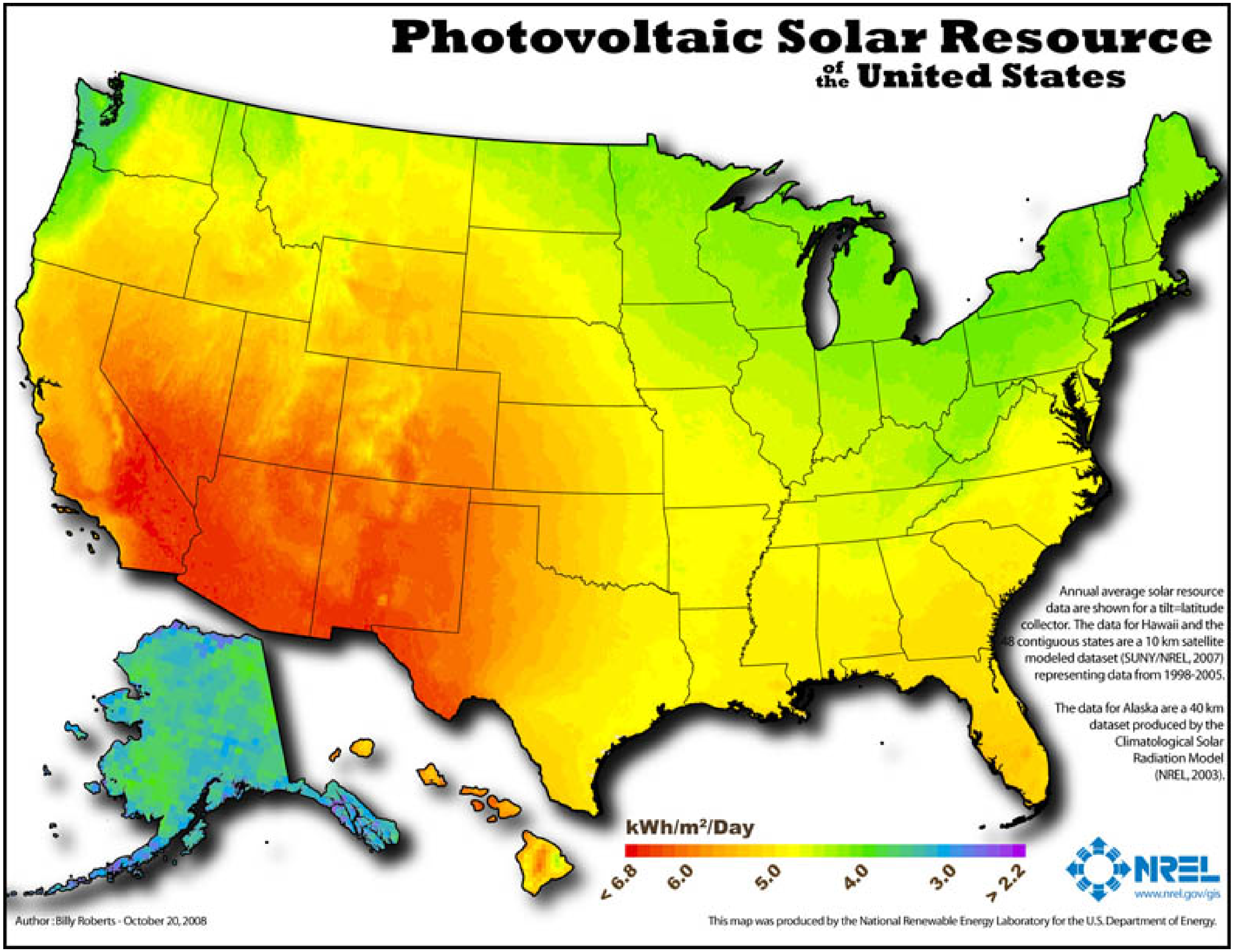

Figure 13. Average Annual Solar PV Resource at Latitude Fixed Tilt

Source: (NREL 2009)

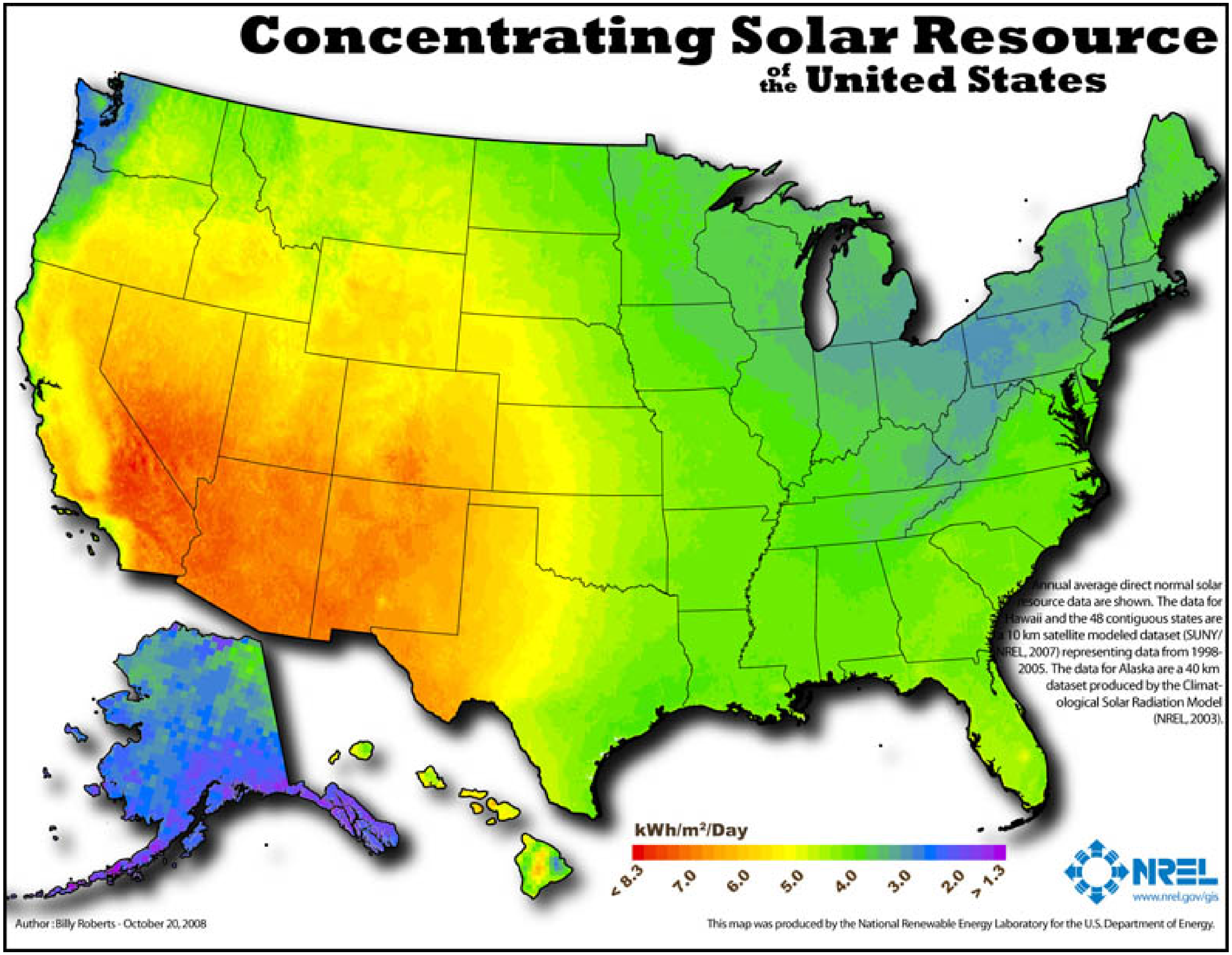

Figure 14. Direct Normal Solar Irradiance Resource Map

Source: (NREL 2009)

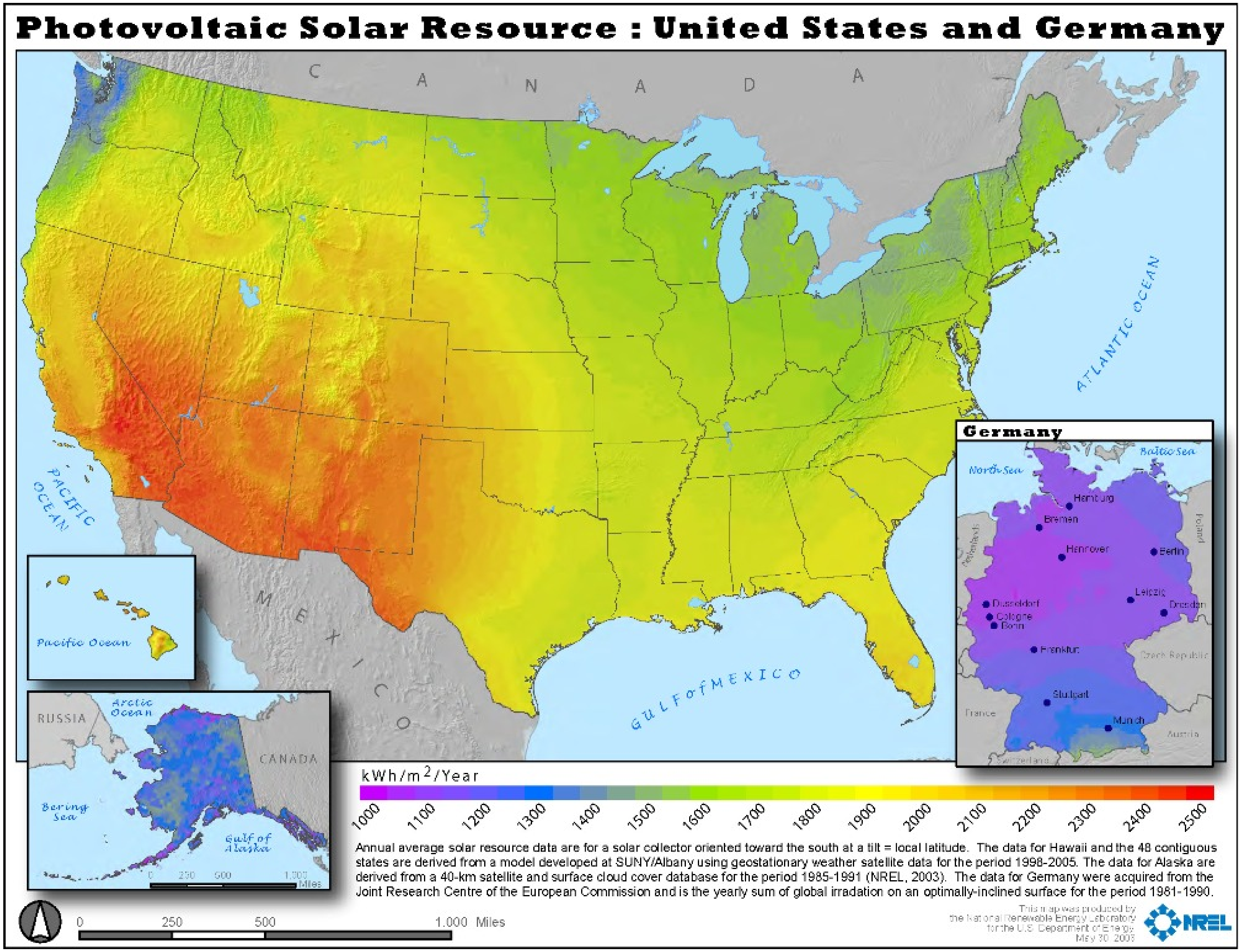

Figure 15. International Photovoltaic Solar Resources

Source: (SEIA 2008)

Appendix D

Renewable Portfolio Standard Summaries

As of September 2010, 29 states plus the District of Columbia had implemented a renewable portfolio standard. Table 18 and Figure 16 combine to present a summary of these states' current deadlines and minimum percentages (targets). Figure 17 is also included to present the 16 states plus the District of Columbia that have included solar carve-out or distributed generation provisions in their RPS.

Table 18. State Renewable Portfolio Standards Milestone Summary

State	Target
Arizona	15% (2025)
California	33% (2020)
Colorado	30% (2020): IOU, 10% (2020): POU
Connecticut	27% (2020)
Delaware	20% (2019)
Hawaii	40% (2030)
Illinois	25% (2025)
Iowa	105 MW (1999)
Kansas	20% (2020)
Maine	40% (2017)
Maryland	20% (2022)
Massachusetts	22.1% (2020)
Michigan	10% (2015) + 1,100 MW
Minnesota	25% (2025), 30% (2020): Xcel
Missouri	15% (2021)
Montana	15% (2015)
Nevada	25% (2025)
New Hampshire	23.8% (2025)
New Jersey	22.5% (2021)
New Mexico	20% (2020): IOU, 10% (2020): Coop
New York	29% (2015)
North Carolina	12.5% (2021): IOU, 10% (2018): POU
Ohio	12.5% (2024)
Oregon	25% (2025): Large, 5-10% (2025): Small
Pennsylvania	18% (2021)
Rhode Island	16% (2019)
Texas	5,880 MW (2015)
Washington	15% (2020)
Washington, DC	20% (2020)
Wisconsin	10% (2015)

Source: (DSIRE-a 2010)

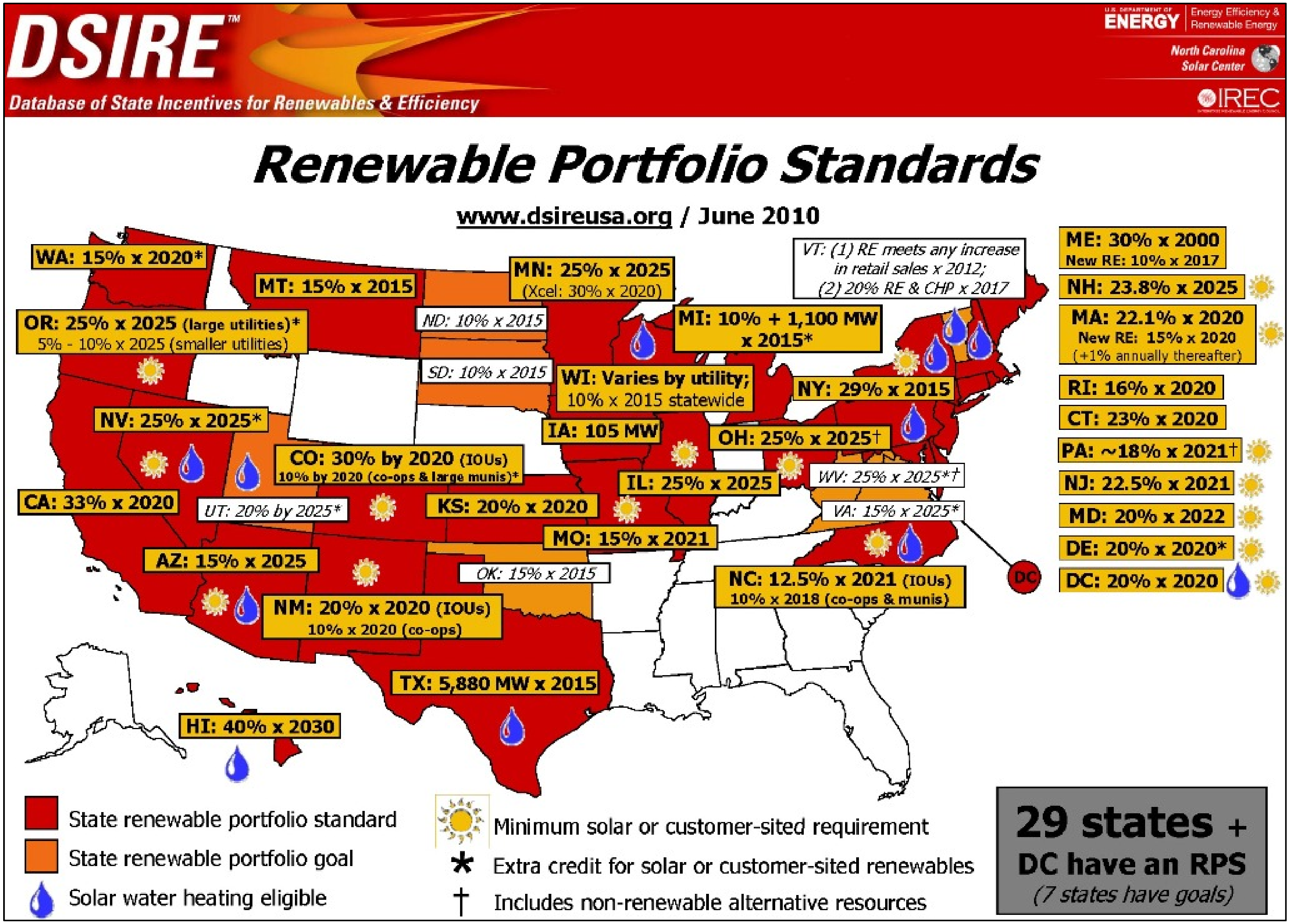

Figure 16. State Renewable Portfolio Statuses

Source: (DSIRE-a 2010)

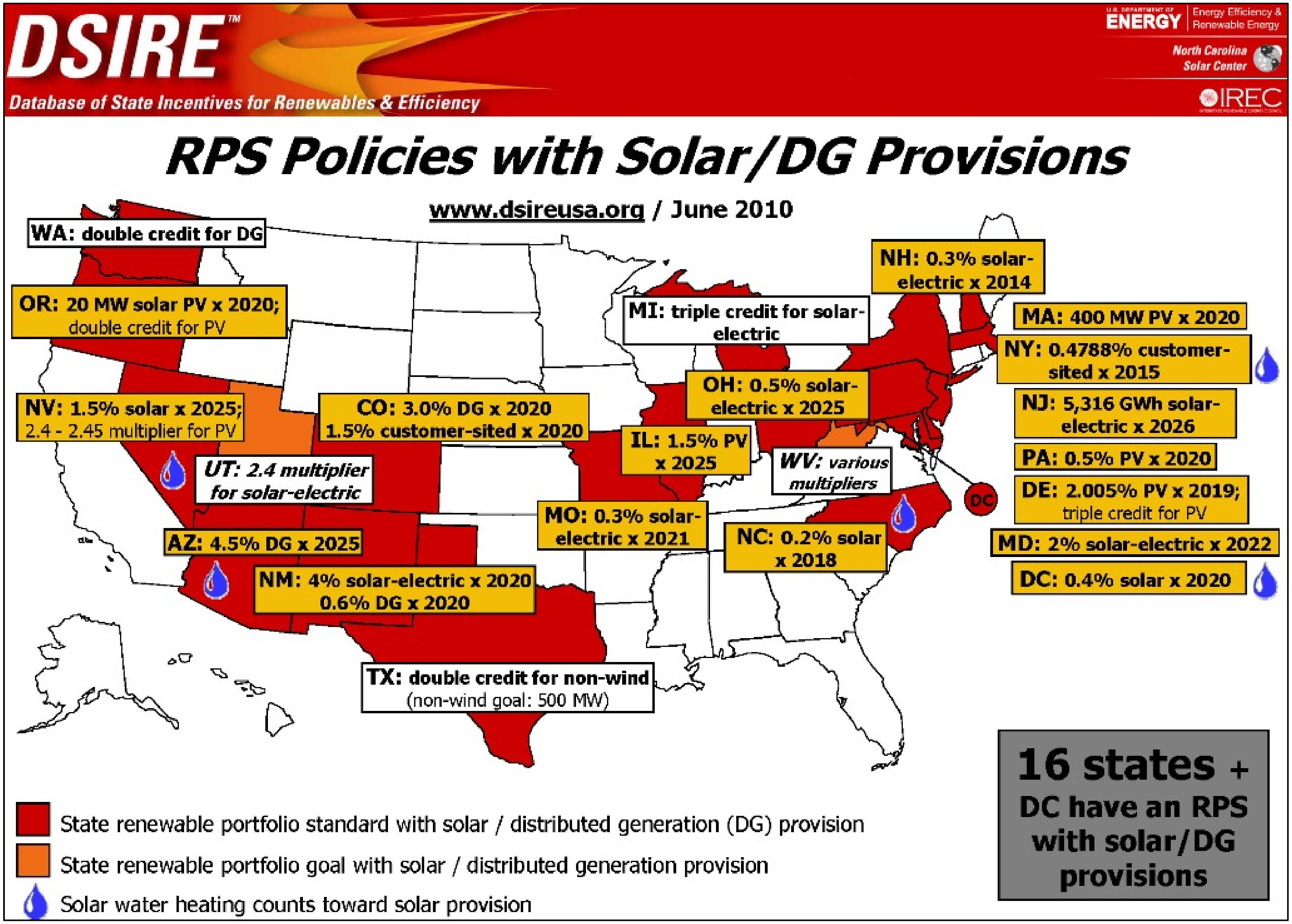

Figure 17. State Renewable Portfolio Standards with Solar/DG Provisions

Source: (DSIRE 2010)

Appendix E

Investigation 1 (Characterization of Carve-Out States) Detailed Tables

As part of the first investigation (characterization of carve-out states) detailed in Section 4 of this report, numerous detailed analyses were completed. The following tables include the detailed research utilized in the completion of these analyses.

Note that bold text in all tables within this appendix denotes a carve-out state.

Table 19. Net Electric Generation by State by Fuel Type (GWh) (2009)

State	Net Generation [1]	Coal [2]	Petroleum Liquid [3]	Petroleum Coke [4]	Natural Gas [5]	Other Gases [6]	Nuclear [7]	Hydro (Conventional) [8]	Other Renewables [9]	Pumped Storage [10]	Other [11]
Alabama	45,376	18,484	66	55	9,284	55	12,733	3,721	1,030	-	2
Alaska	2,270	182	471	-	1,214	-	-	401	-	-	-
Arizona	32,586	11,918	21	-	7,615	-	10,582	2,354	48	48	-
Arkansas	17,447	7,155	55	-	3,385	-	4,952	1,361	512	18	8
California	60,603	640	67	482	33,455	482	9,922	7,527	7,966	(105)	139
Colorado	16,544	9,621	3	-	4,976	-	-	700	1,268	(33)	10
Connecticut	10,740	935	184	-	2,891	-	6,064	204	243	(2)	221
Delaware	**1,681**	**1,202**	**153**	**39**	**237**	**39**	**-**	**-**	**50**	**-**	**1**
District of Columbia	**9**	**-**	**9**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Florida	62,892	15,874	1,587	3	31,472	3	10,506	79	1,357	-	801
Georgia	38,660	20,455	66	-	5,983	-	10,164	852	890	84	6
Hawaii	3,318	465	2,501	13	-	13	-	37	246	-	57
Idaho	3,791	26	-	-	391	-	-	3,108	265	-	-
Illinois	**64,025**	**29,336**	**40**	**10**	**1,447**	**10**	**31,757**	**55**	**1,358**	**-**	**22**
Indiana	39,867	37,254	49	472	1,310	472	-	155	537	-	91
Iowa	17,106	12,233	14	-	444	-	1,160	264	2,982	-	-
Kansas	15,078	10,228	16	-	608	-	3,341	-	851	-	-
Kentucky	30,419	27,883	42	2	287	2	-	1,279	150	-	7
Louisiana	27,878	6,786	40	380	12,466	380	6,249	421	785	-	105
Maine	5,540	39	354	-	2,141	-	-	1,604	1,291	-	112
Maryland	**15,497**	**9,164**	**228**	**54**	**504**	**54**	**4,550**	**735**	**181**	**-**	**81**
Massachusetts	**13,035**	**3,683**	**707**	**-**	**5,957**	**-**	**1,732**	**424**	**413**	**(136)**	**254**
Michigan	32,052	22,204	68	52	2,678	52	5,896	458	805	(252)	84
Minnesota	18,210	10,567	35	-	637	-	4,059	240	2,558	-	111
Mississippi	14,482	3,506	9	12	6,865	12	3,648	-	441	-	-
Missouri	**28,053**	**22,876**	**13**	**2**	**1,161**	**2**	**3,087**	**573**	**165**	**156**	**9**
Montana	9,039	5,917	3	-	-	-	-	2,539	353	-	43
Nebraska	10,421	6,590	3	-	56	-	3,540	126	106	-	-
Nevada	**11,718**	**2,601**	**5**	**1**	**7,785**	**1**	**-**	**747**	**580**	**-**	**-**
New Hampshire	**7,786**	**1,322**	**119**	**-**	**1,874**	**-**	**3,583**	**544**	**325**	**-**	**19**
New Jersey	**19,155**	**1,828**	**228**	**39**	**5,533**	**39**	**11,119**	**-**	**300**	**(66)**	**162**
New Mexico	**12,540**	**9,054**	**15**	**-**	**2,763**	**-**	**-**	**104**	**604**	**-**	**-**
New York	45,015	5,138	1,720	-	13,244	-	13,819	9,407	1,497	(154)	313
North Carolina	**37,837**	**21,589**	**135**	**-**	**999**	**-**	**13,073**	**1,338**	**634**	**43**	**26**
North Dakota	11,598	10,098	16	-	-	-	-	407	1,076	-	-
Ohio	**44,748**	**38,915**	**81**	**29**	**1,204**	**29**	**3,833**	**136**	**205**	**-**	**4**
Oklahoma	23,788	11,109	-	-	10,759	-	-	1,057	891	(38)	-
Oregon	**19,975**	**1,224**	**2**	**-**	**5,032**	**-**	**-**	**12,422**	**1,282**	**-**	**13**
Pennsylvania	**72,560**	**35,535**	**504**	**148**	**8,350**	**148**	**25,732**	**1,012**	**1,009**	**(75)**	**277**
Rhode Island	2,363	-	-	-	2,305	-	-	-	50	-	-
South Carolina	32,193	11,356	51	-	1,936	-	17,853	574	590	(282)	34
South Dakota	2,340	1,156	6	-	-	-	-	1,010	129	-	8
Tennessee	26,686	14,798	73	4	121	4	8,922	2,665	288	(185)	-
Texas	114,724	42,036	21	1,164	48,281	1,164	14,700	407	7,555	-	184
Utah	14,189	11,472	15	12	2,291	12	-	229	104	-	66
Vermont	2,462	-	-	-	1	-	1,788	549	123	-	-
Virginia	24,207	9,783	818	-	3,470	-	9,141	383	837	(367)	141
Washington	35,251	3,033	10	56	2,329	56	2,930	25,211	1,646	14	21
West Virginia	25,016	24,038	51	8	43	8	-	565	311	-	-
Wisconsin	20,054	11,708	18	-	2,133	-	4,543	542	854	-	21
Wyoming	15,059	13,681	12	103	203	103	-	284	776	-	-
U.S. Total	1,257,883	576,699	10,716	3,148	258,173	3,148	264,979	88,825	48,523	(1,332)	3,457

Notes:
[1] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_6_b.html
[2] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_7_b.html
[3] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_8_a.html
[4] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_9_b.html
[5] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_10_b.html
[6] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_11_b.html
[7] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_12_b.html
[8] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_13_b.html
[9] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_14_b.html
[10] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_15_b.html
[11] Source: http://www.eia.doe.gov/cneaf/electricity/epm/table1_16_b.html

Table 20. Average Retail Electric Rates by State by Sector (¢/kWh) (2009)

State	Residential	Commercial	Industrial	All Sectors
Alabama	$ 10.51	$ 10.14	$ 6.08	$ 8.84
Alaska	$ 17.27	$ 14.56	$ 12.58	$ 15.17
Arizona	$ 9.95	$ 8.72	$ 6.05	$ 8.73
Arkansas	$ 9.11	$ 7.63	$ 5.86	$ 7.68
California	$ 14.51	$ 12.29	$ 9.25	$ 12.50
Colorado	$ 9.40	$ 7.46	$ 5.86	$ 7.74
Connecticut	$ 20.09	$ 17.12	$ 16.14	$ 18.28
Delaware	**$ 13.53**	**$ 12.05**	**$ 9.84**	**$ 12.20**
District of Columbia	**$ 12.82**	**$ 14.13**	**$ 10.17**	**$ 13.78**
Florida	$ 12.46	$ 11.05	$ 9.41	$ 11.62
Georgia	$ 9.54	$ 8.86	$ 5.99	$ 8.50
Hawaii	$ 23.30	$ 20.89	$ 17.19	$ 20.30
Idaho	$ 7.19	$ 6.09	$ 4.39	$ 6.08
Illinois	**$ 11.39**	**$ 8.47**	**$ 7.71**	**$ 9.31**
Indiana	$ 9.10	$ 8.26	$ 5.84	$ 7.56
Iowa	$ 9.25	$ 7.00	$ 4.91	$ 6.92
Kansas	$ 9.01	$ 7.68	$ 6.12	$ 7.74
Kentucky	$ 8.25	$ 7.66	$ 4.84	$ 6.47
Louisiana	$ 8.80	$ 8.77	$ 6.33	$ 7.96
Maine	$ 15.65	$ 13.39	$ 10.90	$ 13.66
Maryland	**$ 14.69**	**$ 12.23**	**$ 10.53**	**$ 13.22**
Massachusetts	**$ 17.89**	**$ 18.69**	**$ 11.13**	**$ 16.04**
Michigan	$ 10.98	$ 9.15	$ 6.90	$ 9.17
Minnesota	$ 9.78	$ 7.70	$ 6.13	$ 7.98
Mississippi	$ 10.05	$ 9.77	$ 6.91	$ 8.96
Missouri	**$ 7.48**	**$ 6.09**	**$ 4.88**	**$ 6.50**
Montana	$ 8.58	$ 8.17	$ 5.67	$ 7.41
Nebraska	$ 7.51	$ 6.90	$ 5.59	$ 6.74
Nevada	**$ 12.57**	**$ 10.79**	**$ 7.08**	**$ 9.78**
New Hampshire	**$ 16.54**	**$ 15.35**	**$ 14.34**	**$ 15.70**
New Jersey	**$ 15.93**	**$ 14.12**	**$ 10.91**	**$ 14.45**
New Mexico	**$ 9.81**	**$ 8.51**	**$ 6.02**	**$ 8.17**
New York	$ 16.94	$ 14.69	$ 9.77	$ 15.02
North Carolina	**$ 9.66**	**$ 7.82**	**$ 5.71**	**$ 8.29**
North Dakota	$ 6.90	$ 6.46	$ 5.69	$ 6.45
Ohio	**$ 9.90**	**$ 9.47**	**$ 6.69**	**$ 8.72**
Oklahoma	$ 8.39	$ 6.75	$ 4.99	$ 6.92
Oregon	**$ 8.51**	**$ 8.13**	**$ 5.05**	**$ 7.62**
Pennsylvania	**$ 11.10**	**$ 9.41**	**$ 7.30**	**$ 9.48**
Rhode Island	$ 16.80	$ 13.96	$ 13.65	$ 14.99
South Carolina	$ 10.02	$ 8.50	$ 5.65	$ 8.16
South Dakota	$ 7.88	$ 6.81	$ 5.63	$ 7.09
Tennessee	$ 9.60	$ 10.00	$ 7.13	$ 9.05
Texas	$ 13.02	$ 10.13	$ 7.62	$ 10.44
Utah	$ 8.04	$ 6.47	$ 4.42	$ 6.31
Vermont	$ 14.63	$ 12.65	$ 9.36	$ 12.65
Virginia	$ 10.19	$ 8.23	$ 6.99	$ 8.92
Washington	$ 7.63	$ 7.07	$ 4.39	$ 6.74
West Virginia	$ 7.64	$ 6.71	$ 5.10	$ 6.54
Wisconsin	$ 11.91	$ 9.47	$ 6.67	$ 9.38
Wyoming	$ 8.10	$ 7.04	$ 4.63	$ 5.93
U.S. Total	$ 11.23	$ 10.06	$ 6.82	$ 9.72

Source: (EIA-e 2010)

Table 21. Energy Consumption by State (2008)

State	Total Consumption (Trillion Btu) [1]	Net Interstate Flow of Electricity / Losses [2] [3]	Net Electricity Imports [4]	Population Estimate [5]	Per Capita Consumption (MMBtu/Person)
Alabama	2,065	(439)	-	4,627,851	446
Alaska	651	-	-	686,293	948
Arizona	1,553	(296)	(1)	6,500,180	239
Arkansas	1,125	(36)	-	2,855,390	394
California	8,382	961	16	36,756,666	228
Colorado	1,498	26	-	4,861,515	308
Connecticut	810	35	7	3,501,252	231
Delaware	**295**	**53**	**-**	**873,092**	**338**
District of Columbia	**180**	**127**	**-**	**591,833**	**305**
Florida	4,447	432	-	18,328,340	243
Georgia	3,015	152	-	9,685,744	311
Hawaii	284	-	-	1,288,198	220
Idaho	529	147	(0)	1,523,816	347
Illinois	**4,089**	**(512)**	**0**	**12,901,563**	**317**
Indiana	2,857	(171)	(0)	6,376,792	448
Iowa	1,414	(56)	-	3,002,555	471
Kansas	1,136	(78)	-	2,802,134	405
Kentucky	1,983	(25)	-	4,269,245	464
Louisiana	3,488	146	-	4,410,796	791
Maine	469	6	4	1,316,456	356
Maryland	**1,447**	**196**	**-**	**5,633,597**	**257**
Massachusetts	**1,475**	**206**	**14**	**6,497,967**	**227**
Michigan	2,918	(48)	8	10,003,422	292
Minnesota	1,979	151	27	5,220,393	379
Mississippi	1,186	69	-	2,938,618	403
Missouri	**1,937**	**(24)**	**1**	**5,911,605**	**328**
Montana	434	(150)	(1)	967,440	449
Nebraska	782	(30)	-	1,783,432	438
Nevada	**750**	**58**	**0**	**2,600,167**	**288**
New Hampshire	**311**	**(109)**	**3**	**1,315,809**	**237**
New Jersey	**2,637**	**241**	**-**	**8,682,661**	**304**
New Mexico	**693**	**(136)**	**(0)**	**1,984,356**	**349**
New York	3,988	108	45	19,490,297	205
North Carolina	**2,702**	**147**	**-**	**9,222,414**	**293**
North Dakota	441	(230)	3	641,481	687
Ohio	**3,987**	**163**	**-**	**11,485,910**	**347**
Oklahoma	1,603	(125)	-	3,642,361	440
Oregon	**1,105**	**7**	**1**	**3,790,060**	**291**
Pennsylvania	**3,900**	**(611)**	**2**	**12,448,279**	**313**
Rhode Island	220	26	2	1,050,788	209
South Carolina	1,660	(156)	-	4,479,800	370
South Dakota	350	45	-	804,194	435
Tennessee	2,261	210	-	6,214,888	364
Texas	11,552	82	(0)	24,326,974	475
Utah	799	(144)	(0)	2,736,424	292
Vermont	154	(18)	8	621,270	249
Virginia	2,514	443	-	7,769,089	324
Washington	2,050	(109)	(25)	6,549,224	313
West Virginia	831	(539)	-	1,814,468	458
Wisconsin	1,862	111	-	5,627,967	331
Wyoming	542	(305)	(0)	532,668	1,017
U.S. Total	99,382	-	112	303,947,734	327

Notes:
[1] Source: http://www.eia.gov/emeu/states/hf.jsp?incfile=sep_sum/plain_html/sum_btu_1html
[2] Source: http://www.eia.gov/emeu/states/hf.jsp?incfile=sep_sum/plain_html/sum_btu_1html
[3] Net interstate flow of electricity / losses is difference in amount of electricity sold within a state (including associated losses) and energy input at the electric utilities within a state. Positive number indicates that more electricity came into the state than went out.
[4] Source: http://www.eia.gov/emeu/states/hf.jsp?incfile=sep_sum/plain_html/sum_btu_1html
[5] Source: http://www.census.gov/

Table 22. CO_2 Emissions by State (2007)

State	Total CO_2 Released (MMT) [1]	Population Estimate [2]	Per Capita CO_2 Emissions (Tons/Person)
Alabama	146.0	4,627,851	34.8
Alaska	44.0	683,478	71.0
Arizona	102.0	6,338,755	17.7
Arkansas	64.3	2,834,797	25.0
California	402.1	36,553,215	12.1
Colorado	98.9	4,861,515	22.4
Connecticut	40.3	3,502,309	12.7
Delaware	**17.3**	**864,764**	**22.0**
District of Columbia	**2.5**	**588,292**	**4.7**
Florida	258.1	18,251,243	15.6
Georgia	185.6	9,544,750	21.4
Hawaii	24.3	1,283,388	20.9
Idaho	16.2	1,499,402	11.9
Illinois	**243.3**	**12,852,548**	**20.9**
Indiana	235.6	6,345,289	40.9
Iowa	84.0	2,988,046	31.0
Kansas	80.6	2,775,997	32.0
Kentucky	157.7	4,241,474	41.0
Louisiana	185.9	4,293,204	47.7
Maine	19.9	1,317,207	16.6
Maryland	**77.7**	**5,618,344**	**15.2**
Massachusetts	**80.1**	**6,449,755**	**13.7**
Michigan	183.9	10,071,822	20.1
Minnesota	100.6	5,197,621	21.3
Mississippi	67.4	2,918,785	25.4
Missouri	**140.5**	**5,878,415**	**26.4**
Montana	37.7	957,861	43.4
Nebraska	44.0	1,774,571	27.3
Nevada	**41.6**	**2,565,382**	**17.9**
New Hampshire	**19.1**	**1,315,828**	**16.0**
New Jersey	**132.7**	**8,685,920**	**16.8**
New Mexico	**59.2**	**1,969,915**	**33.1**
New York	200.3	19,297,729	11.4
North Carolina	**155.0**	**9,061,032**	**18.9**
North Dakota	52.5	639,715	90.5
Ohio	**269.4**	**11,466,917**	**25.9**
Oklahoma	110.3	3,617,316	33.6
Oregon	**43.5**	**3,747,455**	**12.8**
Pennsylvania	**278.0**	**12,432,792**	**24.7**
Rhode Island	10.8	1,057,832	11.3
South Carolina	87.6	4,407,709	21.9
South Dakota	13.8	796,214	19.1
Tennessee	126.7	6,156,719	22.7
Texas	639.5	23,904,380	29.5
Utah	70.4	2,645,330	29.3
Vermont	6.5	621,254	11.5
Virginia	128.9	7,712,091	18.4
Washington	82.0	6,468,424	14.0
West Virginia	117.1	1,812,035	71.2
Wisconsin	105.0	5,601,640	20.7
Wyoming	64.7	522,830	136.5
U.S. Total	5,955.2	301,621,157	21.8

Notes:
[1] Source: http://www.eia.doe.gov/oiaf/1605/state/state_emissions.html
[2] Source: http://www.census.gov/

Table 23. Nonattainment Statuses (2010)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
AK	**Anchorage**				
	PM-10	Eagle River, AK	195	1	Moderate
AK	**Fairbanks**				
	PM-2.5 2006	Fairbanks, AK	71	1	Nonattainment
AK	**Juneau**				
	PM-10	Juneau, AK	14	1	Moderate
AL	**Birmingham**				
	PM-2.5 1997	Birmingham, AL	808	3	Nonattainment
	PM-2.5 2006	Birmingham, AL	808	3	Nonattainment
AZ	**Ajo**				
	PM-10	Ajo (Pima County), AZ	8	1	Moderate
AZ	**Douglas (Cochise County)**				
	PM-10	Paul Spur/Douglas (Cochise County), AZ	16	1	Moderate
AZ	**Hayden/Miami**				
	PM-10	Miami, AZ	15	1	Moderate
	SO2	Hayden (Pinal County), AZ	4	1	Primary
AZ	**Nogales**				
	PM-10	Nogales, AZ	25	1	Moderate
	PM-2.5 2006	Nogales, AZ	26	1	Nonattainment
AZ	**Phoenix-Mesa**				
	8-Hr Ozone	Phoenix-Mesa, AZ	3,086	2	Former Subpart 1
	PM-10	Phoenix, AZ	3,112	2	Serious
AZ	**Rillito (Pima County)**				
	PM-10	Rillito, AZ	1	1	Moderate
AZ	**Yuma**				
	PM-10	Yuma, AZ	82	1	Moderate
CA	**Amador and Calaveras Cos (Central Mtn),**				
	8-Hr Ozone	Amador and Calaveras Cos (Central Mtn), CA	76	2	Former Subpart 1
CA	**Chico**				
	8-Hr Ozone	Chico, CA	203	1	Former Subpart 1
	PM-2.5 2006	Chico, CA	199	1	Nonattainment
CA	**Imperial County**				
	8-Hr Ozone	Imperial Co, CA	142	1	Moderate
	PM-10	Imperial Valley, CA	120	1	Serious
	PM-2.5 2006	Imperial Co, CA	123	1	Nonattainment
CA	**Kern Co (Eastern Kern)**				
	8-Hr Ozone	Kern Co (Eastern Kern), CA	99	1	Former Subpart 1
CA	**Los Angeles-San Bernardino Cos(W Mojave)**				
	8-Hr Ozone	Los Angeles-San Bernardino Cos(W Mojave),CA	656	2	Moderate
	PM-10	Coachella Valley, CA	182	1	Serious
	PM-10	San Bernardino Co, CA	199	1	Moderate
CA	**Los Angeles-South Coast Air Basin**				
	8-Hr Ozone	Los Angeles South Coast Air Basin, CA	14,594	4	Extreme
	PM-10	Los Angeles South Coast Air Basin, CA	14,594	4	Serious
	PM-2.5 1997	Los Angeles-South Coast Air Basin, CA	14,594	4	Nonattainment
	PM-2.5 2006	Los Angeles-South Coast Air Basin, CA	14,594	4	Nonattainment
CA	**Mariposa and Tuolumne Cos (Southern Mtn)**				
	8-Hr Ozone	Mariposa and Tuolumne Cos (Southern Mtn),CA	72	2	Former Subpart 1
CA	**Mono County**				
	PM-10	Mammoth Lake, CA	6	1	Moderate
	PM-10	Mono Basin, CA	0	1	Moderate
CA	**Nevada Co. (Western Part)**				
	8-Hr Ozone	Nevada Co. (Western Part), CA	78	1	Former Subpart 1

Table 23. Nonattainment Statuses (2010) (cont.)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
CA	**Owens Valley**				
	PM-10	Owens Valley, CA	7	1	Serious
CA	**Riverside Co, (Coachella Valley)**				
	8-Hr Ozone	Riverside Co, (Coachella Valley), CA	325	1	Severe 15
CA	**Sacramento Metro**				
	8-Hr Ozone	Sacramento Metro, CA	1,978	6	Severe 15
	PM-10	Sacramento Co, CA	1,223	1	Moderate
	PM-2.5 2006	Sacramento, CA	1,916	5	Nonattainment
CA	**San Diego**				
	8-Hr Ozone	San Diego, CA	2,813	1	Former Subpart 1
CA	**San Francisco-Bay Area**				
	8-Hr Ozone	San Francisco Bay Area, CA	6,542	9	Marginal
	PM-2.5 2006	San Francisco Bay Area, CA	6,542	9	Nonattainment
CA	**San Joaquin Valley**				
	8-Hr Ozone	San Joaquin Valley, CA	3,191	8	Extreme
	PM-10	East Kern Co, CA	99	1	Serious
	PM-2.5 1997	San Joaquin Valley, CA	3,191	8	Nonattainment
	PM-2.5 2006	San Joaquin Valley, CA	3,191	8	Nonattainment
CA	**Searles Valley**				
	PM-10	Coso Junction, CA	7	1	Moderate
	PM-10	Trona, CA	4	1	Moderate
CA	**Sutter Co (Sutter Buttes)**				
	8-Hr Ozone	Sutter Co (Sutter Buttes), CA	0	1	Former Subpart 1
CA	**Ventura County**				
	8-Hr Ozone	Ventura Co, CA	753	1	Serious
CA	**Yuba City**				
	PM-2.5 2006	Yuba City-Marysville, CA	137	2	Nonattainment
CO	**Denver-Boulder-Greeley-Ft Collins-Love.**				
	8-Hr Ozone	Denver-Boulder-Greeley-Ft Collins-Love., CO	2,812	9	Former Subpart 1
CT	**Greater Connecticut**				
	8-Hr Ozone	Greater Connecticut, CT	1,544	5	Moderate
DC-MD-VA	**Washington**				
	8-Hr Ozone	Washington, DC-MD-VA	4,452	15	Moderate
	PM-2.5 1997	Washington, DC-MD-VA	4,378	14	Nonattainment
GA	**Atlanta**				
	8-Hr Ozone	Atlanta, GA	4,228	20	Moderate
	PM-2.5 1997	Atlanta, GA	4,232	22	Nonattainment
GA	**Macon**				
	PM-2.5 1997	Macon, GA	155	2	Nonattainment
GA	**Rome, GA**				
	PM-2.5 1997	Rome, GA	91	1	Nonattainment
GU	**Piti Power Plant**				
	SO2	Piti, GU	1	1	Primary
GU	**Tanguisson Power Plant**				
	SO2	Tanguisson, GU	1	1	Primary
ID	**Bonner County (Sandpoint)**				
	PM-10	Bonner Co (Sandpoint), ID	37	1	Moderate
ID	**Pocatello**				
	PM-10	Fort Hall Indian Reservation, ID	1	2	Moderate
ID	**Shoshone County**				
	PM-10	Shoshone Co, ID	10	1	Moderate
	PM-10	Pinehurst, ID	2	1	Moderate

Table 23. Nonattainment Statuses (2010) (cont.)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
IL-IN	**Chicago-Gary-Lake County**				
	8-Hr Ozone	Chicago-Gary-Lake County, IL-IN (Illinois portion)	8,126	8	Moderate
	PM-2.5 1997	Chicago-Gary-Lake County, IL-IN	8,758	10	Nonattainment
IN	**Evansville**				
	PM-2.5 1997	Evansville, IN	277	6	Nonattainment
IN	**Indianapolis**				
	PM-2.5 1997	Indianapolis, IN	1,329	5	Nonattainment
KY-IN	**Louisville**				
	PM-2.5 1997	Louisville, KY-IN	939	5	Nonattainment
LA	**Baton Rouge**				
	8-Hr Ozone	Baton Rouge, LA	636	5	Moderate
MA	**Boston-Lawrence-Worcester (E. Mass)**				
	8-Hr Ozone	Boston-Lawrence-Worcester (E. MA), MA	5,534	10	Moderate
MA	**Springfield (Western Mass)**				
	8-Hr Ozone	Springfield (Western MA), MA	815	4	Moderate
MD	**Baltimore**				
	8-Hr Ozone	Baltimore, MD	2,512	6	Moderate
	PM-2.5 1997	Baltimore, MD	2,512	6	Nonattainment
MD	**Washington County (Hagerstown), MD**				
	PM-2.5 1997	Martinsburg, WV-Hagerstown, MD	208	2	Nonattainment
MI	**Allegan County**				
	8-Hr Ozone	Allegan Co, MI	106	1	Former Subpart 1
MI	**Detroit-Ann Arbor-Flint**				
	PM-2.5 1997	Detroit-Ann Arbor, MI	4,833	7	Nonattainment
	PM-2.5 2006	Detroit-Ann Arbor, MI	4,833	7	Nonattainment
MO-IL	**St. Louis**				
	8-Hr Ozone	St Louis, MO-IL	2,505	9	Moderate
	Lead	Jefferson County (part); Herculaneum, MO	2	1	
	PM-2.5 1997	St. Louis, MO-IL	2,487	9	Nonattainment
MT	**Billings/Laurel**				
	SO2	Laurel Area (Yellowstone County), MT	6	1	Primary
MT	**Butte**				
	PM-10	Butte, MT	35	1	Moderate
MT	**Columbia Falls (Flathead County)**				
	PM-10	Columbia Falls, MT	4	1	Moderate
MT	**East Helena**				
	Lead	East Helena Area (Lewis and Clark Co.), MT	2	1	
	SO2	East Helena Area (Lewis and Clark Co.), MT	2	1	Primary, Secondary
MT	**Kalispell (Flathead County)**				
	PM-10	Kalispell, MT	15	1	Moderate
MT	**Lame Deer**				
	PM-10	Lame Deer, MT	1	1	Moderate
MT	**Libby**				
	PM-10	Libby, MT	3	1	Moderate
	PM-2.5 1997	Libby, MT	3	1	Nonattainment
MT	**Missoula**				
	PM-10	Missoula, MT	52	1	Moderate
MT	**Polson (Lake County)**				
	PM-10	Polson, MT	4	1	Moderate
MT	**Ronan (Lake County)**				
	PM-10	Ronan, MT	3	1	Moderate
MT	**Thompson Falls**				
	PM-10	Sanders County (part);Thompson Falls and vicinity,MT	1	1	Moderate

Table 23. Nonattainment Statuses (2010) (cont.)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
MT	**Whitefish (Flathead County)**				
	PM-10	Flathead County; Whitefish and vicinity, MT	5	1	Moderate
NC	**Greensboro-Winston-Salem-High Point**				
	PM-2.5 1997	Greensboro-Winston Salem-High Point, NC	568	2	Nonattainment
NC	**Hickory-Morganton-Lenoir**				
	PM-2.5 1997	Hickory, NC	142	1	Nonattainment
NC-SC	**Charlotte-Gastonia-Rock Hill**				
	8-Hr Ozone	Charlotte-Gastonia-Rock Hill, NC-SC	1,477	8	Moderate
NH	**Boston-Manchester-Portsmouth(SE)**				
	8-Hr Ozone	Boston-Manchester-Portsmouth(SE),NH	697	4	Moderate
NM	**Anthony**				
	PM-10	Anthony, NM	3	1	Moderate
NV	**Las Vegas**				
	CO	Las Vegas, NV	479	1	Serious
	8-Hr Ozone	Las Vegas, NV	1,349	1	Former Subpart 1
	PM-10	Clark Co, NV	1,376	1	Serious
NV	**Reno**				
	PM-10	Washoe Co, NV	339	1	Serious
NY	**Albany-Schenectady-Troy**				
	8-Hr Ozone	Albany-Schenectady-Troy, NY	924	7	Former Subpart 1
NY	**Buffalo-Niagara Falls**				
	8-Hr Ozone	Buffalo-Niagara Falls, NY	1,170	2	Former Subpart 1
NY	**Essex County; Whiteface Mountain**				
	8-Hr Ozone	Essex Co (Whiteface Mtn), NY	1	1	Former Subpart 1
NY	**Jamestown**				
	8-Hr Ozone	Jamestown, NY	140	1	Former Subpart 1
NY	**Jefferson County**				
	8-Hr Ozone	Jefferson Co, NY	112	1	Moderate
NY	**Poughkeepsie**				
	8-Hr Ozone	Poughkeepsie, NY	717	3	Moderate
NY	**Rochester**				
	8-Hr Ozone	Rochester, NY	1,098	6	Former Subpart 1
NY-NJ-CT	**New York-N. New Jersey-Long Island**				
	8-Hr Ozone	New York-N. New Jersey-Long Island,NY-NJ-CT	19,634	24	Moderate
	PM-10	New York Co, NY	1,537	1	Moderate
	PM-2.5 1997	New York-N. New Jersey-Long Island,NY-NJ-CT	19,803	22	Nonattainment
	PM-2.5 2006	New York-N. New Jersey-Long Island, NY-NJ-CT	19,803	22	Nonattainment
OH	**Canton-Massillon**				
	PM-2.5 1997	Canton-Massillon, OH	378	1	Nonattainment
	PM-2.5 2006	Canton-Massillon, OH	378	1	Nonattainment
OH	**Cleveland-Akron-Lorain**				
	PM-2.5 1997	Cleveland-Akron-Lorain, OH	2,775	7	Nonattainment
	PM-2.5 2006	Cleveland-Akron-Lorain, OH	2,752	6	Nonattainment
OH	**Columbus**				
	PM-2.5 1997	Columbus, OH	1,449	5	Nonattainment
OH	**Dayton-Springfield**				
	PM-2.5 1997	Dayton-Springfield, OH	852	3	Nonattainment
OH-KY-IN	**Cincinnati-Hamilton**				
	8-Hr Ozone	Cincinnati-Hamilton, OH-KY-IN (Kentucky portion)	326	3	Former Subpart 1
	PM-2.5 1997	Cincinnati-Hamilton, OH-KY-IN	1,851	8	Nonattainment
OH-WV	**Steubenville-Weirton**				
	PM-2.5 1997	Steubenville-Weirton, OH-WV	132	3	Nonattainment
	PM-2.5 2006	Steubenville-Weirton, OH-WV	132	3	Nonattainment

Table 23. Nonattainment Statuses (2010) (cont.)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
OR	**Eugene-Springfield**				
	PM-10	Eugene-Springfield, OR	179	1	Moderate
OR	**Klamath Falls**				
	PM-2.5 2006	Klamath Falls, OR	45	1	Nonattainment
OR	**Oakridge**				
	PM-10	Lane Co, OR	3	1	Moderate
	PM-2.5 2006	Oakridge, OR	4	1	Nonattainment
PA	**Allentown-Bethlehem-Easton**				
	PM-2.5 2006	Allentown, PA	579	2	Nonattainment
	SO2	Warren Co, NJ	102	1	Primary, Secondary
PA	**Harrisburg-Lebanon-Carlisle**				
	PM-2.5 1997	Harrisburg-Lebanon-Carlisle, PA	586	3	Nonattainment
	PM-2.5 2006	Harrisburg-Lebanon-Carlisle-York, PA	968	4	Nonattainment
PA	**Johnstown**				
	PM-2.5 1997	Johnstown, PA	164	2	Nonattainment
	PM-2.5 2006	Johnstown, PA	165	2	Nonattainment
PA	**Lancaster**				
	PM-2.5 1997	Lancaster, PA	471	1	Nonattainment
	PM-2.5 2006	Lancaster, PA	471	1	Nonattainment
PA	**Pittsburgh-Beaver Valley**				
	8-Hr Ozone	Pittsburgh-Beaver Valley, PA	2,431	7	Former Subpart 1
	PM-2.5 1997	Liberty-Clairton, PA	22	1	Nonattainment
	PM-2.5 1997	Pittsburgh-Beaver Valley, PA	2,195	8	Nonattainment
	PM-2.5 2006	Liberty-Clairton, PA	22	1	Nonattainment
	PM-2.5 2006	Pittsburgh-Beaver Valley, PA	2,195	8	Nonattainment
	SO2	Armstrong Co, PA	5	1	Primary
PA	**Reading**				
	PM-2.5 1997	Reading, PA	374	1	Nonattainment
PA	**York**				
	PM-2.5 1997	York, PA	382	1	Nonattainment
PA-NJ-MD-DE	**Philadelphia-Wilmin-Atlantic City**				
	8-Hr Ozone	Philadelphia-Wilmin-Atlantic Ci,PA-NJ-MD-DE	7,333	18	Moderate
	PM-2.5 1997	Philadelphia-Wilmington, PA-NJ-DE	5,537	9	Nonattainment
	PM-2.5 2006	Philadelphia-Wilmington, PA-NJ-DE	5,537	9	Nonattainment
RI	**Providence (all of RI)**				
	8-Hr Ozone	Providence (All RI), RI	1,048	5	Moderate
TN	**Knoxville**				
	8-Hr Ozone	Knoxville, TN	714	7	Former Subpart 1
	PM-2.5 1997	Knoxville, TN	599	5	Nonattainment
	PM-2.5 2006	Knoxville, TN	599	5	Nonattainment
TN-GA	**Chattanooga**				
	PM-2.5 1997	Chattanooga, AL-TN-GA	424	4	Nonattainment
TX	**Beaumont-Port Arthur**				
	8-Hr Ozone	Beaumont-Port Arthur, TX	385	3	Moderate
TX	**Dallas-Fort Worth**				
	8-Hr Ozone	Dallas-Fort Worth, TX	5,031	9	Moderate
TX	**El Paso**				
	PM-10	El Paso Co, TX	564	1	Moderate
TX	**Houston-Galveston-Brazoria**				
	8-Hr Ozone	Houston-Galveston-Brazoria, TX	4,670	8	Severe 15

Table 23. Nonattainment Statuses (2010) (cont.)

State	Simple Name Pollutant	Nonattainment Area Name	2000 Population (1000s)	Number of Counties	Classification
UT	**Logan, UT-ID**				
	PM-2.5 2006	Logan, UT-ID	102	2	Nonattainment
UT	**Ogden**				
	PM-10	Ogden, UT	77	1	Moderate
UT	**Provo**				
	PM-10	Utah Co, UT	369	1	Moderate
	PM-2.5 2006	Provo, UT	368	1	Nonattainment
UT	**Salt Lake City**				
	PM-10	Salt Lake Co, UT	898	1	Moderate
	PM-2.5 2006	Salt Lake City, UT	1,406	5	Nonattainment
	SO2	Salt Lake Co, UT	898	1	Primary, Secondary
UT	**Tooele County**				
	SO2	Tooele Co, UT	41	1	Primary, Secondary
WA	**Seattle-Tacoma**				
	PM-2.5 2006	Tacoma, WA	472	1	Nonattainment
WI	**Door County**				
	8-Hr Ozone	Door Co, WI	28	1	Former Subpart 1
WI	**Manitowoc County**				
	8-Hr Ozone	Manitowoc Co, WI	83	1	Former Subpart 1
WI	**Milwaukee-Racine**				
	8-Hr Ozone	Milwaukee-Racine, WI	1,839	6	Moderate
	PM-2.5 2006	Milwaukee-Racine, WI	1,490	3	Nonattainment
WI	**Sheboygan**				
	8-Hr Ozone	Sheboygan, WI	113	1	Moderate
WV	**Charleston**				
	PM-2.5 1997	Charleston, WV	252	2	Nonattainment
	PM-2.5 2006	Charleston, WV	252	2	Nonattainment
WV-KY	**Huntington-Ashland**				
	PM-2.5 1997	Huntington-Ashland, WV-KY-OH	341	9	Nonattainment
WV-OH	**Parkersburg-Marietta**				
	PM-2.5 1997	Parkersburg-Marietta, WV-OH	153	3	Nonattainment
WV-OH	**Wheeling**				
	PM-2.5 1997	Wheeling, WV-OH	153	3	Nonattainment
WY	**Sheridan**				
	PM-10	Sheridan, WY	16	1	Moderate

Source: (EPA-b 2010)

Table 24. Wealth Indices by State (2008)

State	Median Household Income [1]	Gross Domestic Product ($MM) [2]	Population Estimate [3]	Per Capita GDP
Alabama	$ 54,270	$ 170,014	4,627,851	$ 36,737
Alaska	$ 79,541	$ 47,912	686,293	$ 69,813
Arizona	$ 60,547	$ 248,888	6,500,180	$ 38,289
Arkansas	$ 47,648	$ 98,331	2,855,390	$ 34,437
California	$ 70,029	$ 1,846,757	36,756,666	$ 50,243
Colorado	$ 70,164	$ 248,603	4,861,515	$ 51,137
Connecticut	$ 85,344	$ 216,174	3,501,252	$ 61,742
Delaware	**$ 68,745**	**$ 61,828**	**873,092**	**$ 70,815**
District of Columbia	**$ 66,722**	**$ 97,235**	**591,833**	**$ 164,295**
Florida	$ 57,455	$ 744,120	18,328,340	$ 40,599
Georgia	$ 60,268	$ 397,756	9,685,744	$ 41,066
Hawaii	$ 78,659	$ 63,847	1,288,198	$ 49,563
Idaho	$ 54,695	$ 52,747	1,523,816	$ 34,615
Illinois	**$ 68,958**	**$ 633,697**	**12,901,563**	**$ 49,118**
Indiana	$ 59,380	$ 254,861	6,376,792	$ 39,967
Iowa	$ 61,663	$ 135,702	3,002,555	$ 45,196
Kansas	$ 62,462	$ 122,731	2,802,134	$ 43,799
Kentucky	$ 51,729	$ 156,436	4,269,245	$ 36,643
Louisiana	$ 53,963	$ 222,218	4,410,796	$ 50,380
Maine	$ 57,719	$ 49,709	1,316,456	$ 37,760
Maryland	**$ 84,415**	**$ 273,333**	**5,633,597**	**$ 48,518**
Massachusetts	**$ 81,569**	**$ 364,988**	**6,497,967**	**$ 56,170**
Michigan	$ 60,615	$ 382,544	10,003,422	$ 38,241
Minnesota	$ 71,817	$ 262,847	5,220,393	$ 50,350
Mississippi	$ 46,668	$ 91,782	2,938,618	$ 31,233
Missouri	**$ 58,088**	**$ 237,797**	**5,911,605**	**$ 40,225**
Montana	$ 56,820	$ 35,891	967,440	$ 37,099
Nebraska	$ 62,067	$ 83,273	1,783,432	$ 46,693
Nevada	**$ 64,910**	**$ 131,233**	**2,600,167**	**$ 50,471**
New Hampshire	**$ 76,710**	**$ 60,005**	**1,315,809**	**$ 45,603**
New Jersey	**$ 85,761**	**$ 474,936**	**8,682,661**	**$ 54,699**
New Mexico	**$ 52,172**	**$ 79,901**	**1,984,356**	**$ 40,265**
New York	$ 67,877	$ 1,144,481	19,490,297	$ 58,721
North Carolina	**$ 56,588**	**$ 400,192**	**9,222,414**	**$ 43,393**
North Dakota	$ 61,109	$ 31,208	641,481	$ 48,650
Ohio	**$ 60,061**	**$ 471,508**	**11,485,910**	**$ 41,051**
Oklahoma	$ 53,862	$ 146,448	3,642,361	$ 40,207
Oregon	**$ 61,190**	**$ 161,573**	**3,790,060**	**$ 42,631**
Pennsylvania	**$ 63,316**	**$ 553,301**	**12,448,279**	**$ 44,448**
Rhode Island	$ 71,992	$ 47,364	1,050,788	$ 45,075
South Carolina	$ 55,664	$ 156,384	4,479,800	$ 34,909
South Dakota	$ 60,104	$ 36,959	804,194	$ 45,958
Tennessee	$ 53,799	$ 252,127	6,214,888	$ 40,568
Texas	$ 58,765	$ 1,223,511	24,326,974	$ 50,294
Utah	$ 65,226	$ 109,777	2,736,424	$ 40,117
Vermont	$ 63,438	$ 25,442	621,270	$ 40,952
Virginia	$ 73,192	$ 397,025	7,769,089	$ 51,103
Washington	$ 70,498	$ 322,778	6,549,224	$ 49,285
West Virginia	$ 49,082	$ 61,652	1,814,468	$ 33,978
Wisconsin	$ 65,622	$ 240,429	5,627,967	$ 42,720
Wyoming	$ 66,504	$ 35,310	532,668	$ 66,289
U.S. Total	$ 62,902	$ 277,756	5,959,759	$ 46,605

Appendix F

United States Wind Resource Potential

Table 25 presents estimates of windy land area and wind energy potential by state for areas with at least a 30 percent gross capacity factor at 80 meters above ground level. This data was derived from a 2010 NREL study and is utilized within analyses detailed in Chapter 5 of this report.

Table 25. State Renewable Portfolio Standards Summary

	Windy Land Area >= 30% Gross Capacity Factor at 80m					Wind Energy Potential	
State	Total (km^2)	Excluded (km^2)	Available (km^2)	Available % of State	% of Total Windy Land Excluded	Potential Capacity (MW)	Annual Generation (GWh)
Alabama	80.4	56.7	23.6	0.0%	70.6%	118.2	333.0
Alaska	No Data Provided for Alaska						
Arizona	4,545.0	2,364.1	2,180.8	0.7%	52.0%	10,904.1	30,616.0
Arkansas	4,663.2	2,823.2	1,840.1	1.3%	60.5%	9,200.3	26,906.4
California	26,901.3	20,079.2	6,822.0	1.7%	74.6%	34,110.2	105,646.0
Colorado	95,830.4	18,386.5	77,443.9	28.7%	19.2%	387,219.5	1,288,490.0
Connecticut	31.4	26.1	5.3	0.0%	83.1%	26.5	72.9
Delaware	36.6	34.7	1.9	0.0%	94.8%	9.5	25.6
Florida	9.6	9.5	0.1	0.0%	99.2%	0.4	1.1
Georgia	281.3	255.3	26.0	0.0%	90.7%	130.1	379.6
Hawaii	No Data Provided for Hawaii						
Idaho	13,420.4	9,805.3	3,615.1	1.7%	73.1%	18,075.6	52,118.1
Illinois	70,763.6	20,787.1	49,976.4	34.2%	29.4%	249,882.1	763,529.0
Indiana	46,255.2	16,609.7	29,645.5	31.6%	35.9%	148,227.5	443,912.0
Iowa	134,900.1	20,757.3	114,142.8	78.3%	15.4%	570,714.2	2,026,340.0
Kansas	211,861.3	21,387.1	190,474.2	89.4%	10.1%	952,370.9	3,646,590.0
Kentucky	48.7	36.6	12.1	0.0%	75.1%	60.6	173.3
Louisiana	125.5	43.6	82.0	0.1%	34.7%	409.8	1,100.2
Maine	6,026.5	3,776.2	2,250.2	2.7%	62.7%	11,251.2	33,779.4
Maryland	567.7	271.1	296.6	1.2%	47.8%	1,482.9	4,269.3
Massachusetts	1,709.0	1,503.4	205.6	1.0%	88.0%	1,028.0	3,323.3
Michigan	19,761.3	7,952.9	11,808.5	7.9%	40.2%	59,042.3	169,221.0
Minnesota	121,884.7	24,030.6	97,854.1	44.8%	19.7%	489,270.6	1,679,480.0
Mississippi	No Data Provided for Mississippi						
Missouri	69,676.8	14,805.8	54,871.0	30.4%	21.2%	274,355.1	810,619.0
Montana	232,768.6	43,967.7	188,800.9	49.6%	18.9%	944,004.4	3,228,620.0
Nebraska	199,627.8	16,028.0	183,599.7	91.6%	8.0%	917,998.7	3,540,370.0
Nevada	5,873.6	4,424.2	1,449.4	0.5%	75.3%	7,247.1	20,822.9
New Hampshire	1,663.8	1,236.8	427.1	1.8%	74.3%	2,135.4	6,706.3
New Jersey	280.8	254.5	26.4	0.1%	90.6%	131.8	372.9
New Mexico	111,445.8	13,029.1	98,416.7	31.3%	11.7%	492,083.3	1,644,970.0
New York	17,705.8	12,549.6	5,156.3	4.1%	70.9%	25,781.3	74,695.3
North Carolina	1,155.6	994.1	161.5	0.1%	86.0%	807.7	2,395.4
North Dakota	182,374.6	28,335.4	154,039.2	84.2%	15.5%	770,195.8	2,983,750.0
Ohio	17,189.9	6,205.9	10,983.9	10.3%	36.1%	54,919.7	151,881.0
Oklahoma	123,243.6	19,879.2	103,364.4	57.1%	16.1%	516,822.1	1,788,910.0
Oregon	17,109.8	11,689.7	5,420.1	2.2%	68.3%	27,100.3	80,854.6
Pennsylvania	2,123.5	1,462.1	661.4	0.6%	68.9%	3,307.2	9,673.0
Rhode Island	74.0	64.7	9.3	0.3%	87.4%	46.6	152.6
South Carolina	102.8	65.8	37.0	0.0%	64.0%	185.0	504.2
South Dakota	193,828.3	17,345.8	176,482.5	88.4%	8.9%	882,412.4	3,411,690.0
Tennessee	359.9	298.1	61.9	0.1%	82.8%	309.3	900.0
Texas	435,638.6	55,332.7	380,305.9	55.5%	12.7%	1,901,529.7	6,527,850.0
Utah	5,273.6	2,652.8	2,620.7	1.2%	50.3%	13,103.7	37,103.6
Vermont	2,569.6	1,979.8	589.7	2.4%	77.0%	2,948.7	9,162.6
Virginia	1,567.2	1,208.5	358.7	0.3%	77.1%	1,793.3	5,394.8
Washington	11,932.6	8,236.9	3,695.7	2.1%	69.0%	18,478.5	55,550.2
West Virginia	1,495.2	1,118.6	376.6	0.6%	74.8%	1,883.2	5,820.5
Wisconsin	30,228.8	9,477.3	20,751.4	14.3%	31.4%	103,757.1	300,136.0
Wyoming	146,166.2	35,751.7	110,414.5	43.6%	24.5%	552,072.6	1,944,340.0

Source: (NREL-a 2010)

Information presented in Table 25 was used to develop wind energy gross capacity factor estimates by state. These estimates, shown in Table 26, were derived from a 2010 NREL study and are utilized within analyses detailed in Chapter 5 of this report.

Table 26. Wind Energy Gross Capacity Factor Estimates by State

State	GCF (%)	State	GCF (%)
Alabama	32.2%	Montana	39.0%
Alaska	N/A	Nebraska	44.0%
Arizona	32.1%	Nevada	32.8%
Arkansas	33.4%	New Hampshire	35.9%
California	35.4%	New Jersey	32.3%
Colorado	38.0%	New Mexico	38.2%
Connecticut	31.4%	New York	33.1%
Delaware	30.7%	North Carolina	33.9%
Florida	32.1%	North Dakota	44.2%
Georgia	33.3%	Ohio	31.6%
Hawaii	N/A	Oklahoma	39.5%
Idaho	32.9%	Oregon	34.1%
Illinois	34.9%	Pennsylvania	33.4%
Indiana	34.2%	Rhode Island	37.4%
Iowa	40.5%	South Carolina	31.1%
Kansas	43.7%	South Dakota	44.1%
Kentucky	32.6%	Tennessee	33.2%
Louisiana	30.6%	Texas	39.2%
Maine	34.3%	Utah	32.3%
Maryland	32.9%	Vermont	35.5%
Massachusetts	36.9%	Virginia	34.3%
Michigan	32.7%	Washington	34.3%
Minnesota	39.2%	West Virginia	35.3%
Mississippi	N/A	Wisconsin	33.0%
Missouri	33.7%	Wyoming	40.2%

Appendix G

Investigation 3 (State Case Studies) Detailed Tables for Missouri Case Study

As part of the state case studies detailed in Section 6 of this report, numerous detailed datasets were utilized. The following is an overview of this data for the Missouri case study.

Table 27. Historical Missouri IOU Electric Sales, Customers, and Usage (2001-2008)

	Total Electric Sales in Missouri (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Empire District Electric Company	4,223,367	4,223,934	4,155,083	4,043,707	3,810,907	3,774,381	3,734,580	3,670,565
Kansas City Power & Light	8,777,481	8,980,212	8,692,731	8,623,404	8,179,662	8,256,870	8,186,087	8,183,011
KCP&L Greater Missouri Operations	8,102,792	8,129,074	7,774,701	7,553,520	7,101,608	7,043,933	6,930,424	6,583,322
Union Electric Co	37,980,626	38,827,452	36,864,186	36,273,451	32,150,948	31,901,036	32,261,745	31,565,621
Totals (with Empire)	**59,084,266**	**60,160,672**	**57,486,701**	**56,494,082**	**51,243,125**	**50,976,220**	**51,112,836**	**50,002,519**
Totals (without Empire)	**54,860,899**	**55,936,738**	**53,331,618**	**52,450,375**	**47,432,218**	**47,201,839**	**47,378,256**	**46,331,954**

	Total Residential Electric Sales in Missouri (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Empire District Electric Company	1,742,164	1,714,992	1,680,339	1,663,831	1,507,496	1,526,076	1,520,693	1,480,837
Kansas City Power & Light	2,567,480	2,664,825	2,598,846	2,583,942	2,354,498	2,448,487	2,453,540	2,321,133
KCP&L Greater Missouri Operations	3,535,591	3,606,346	3,425,371	3,391,013	3,067,857	3,100,495	3,041,865	2,853,163
Union Electric Co	13,903,713	14,257,728	13,081,168	13,648,949	12,415,567	12,354,426	12,864,857	12,015,691
Totals (with Empire)	**21,748,948**	**22,243,891**	**20,785,724**	**21,287,735**	**19,345,418**	**19,429,484**	**19,880,955**	**18,670,824**
Totals (without Empire)	**20,006,784**	**20,528,899**	**19,105,385**	**19,623,904**	**17,837,922**	**17,903,408**	**18,360,262**	**17,189,987**

	Total Electric Customers in Missouri (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Empire District Electric Company	148,067	146,553	144,045	140,808	137,951	135,426	133,083	131,225
Kansas City Power & Light	271,440	271,008	270,787	268,787	267,060	265,829	263,450	261,819
KCP&L Greater Missouri Operations	310,924	308,250	304,263	298,083	291,959	286,250	280,097	273,981
Union Electric Co	1,196,119	1,179,789	1,170,738	1,158,996	1,147,263	1,170,848	1,167,937	1,124,721
Totals (with Empire)	**1,926,550**	**1,905,600**	**1,889,833**	**1,866,674**	**1,844,233**	**1,858,353**	**1,844,567**	**1,791,746**
Totals (without Empire)	**1,778,483**	**1,759,047**	**1,745,788**	**1,725,866**	**1,706,282**	**1,722,927**	**1,711,484**	**1,660,521**

	Total Residential Electric Customers in Missouri (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Empire District Electric Company	124,396	123,116	120,928	118,139	115,723	113,472	111,372	109,774
Kansas City Power & Light	238,921	238,659	238,389	236,612	235,351	234,170	232,406	231,005
KCP&L Greater Missouri Operations	272,319	269,597	265,705	260,001	254,260	249,383	244,062	239,214
Union Electric Co	1,039,169	1,027,668	1,020,485	1,010,860	1,001,485	1,017,109	1,015,775	975,879
Totals (with Empire)	**1,674,805**	**1,659,040**	**1,645,507**	**1,625,612**	**1,606,819**	**1,614,134**	**1,603,615**	**1,555,872**
Totals (without Empire)	**1,550,409**	**1,535,924**	**1,524,579**	**1,507,473**	**1,491,096**	**1,500,662**	**1,492,243**	**1,446,098**

	Average Annual Residential Customer Usage in Missouri (kWh/person/year)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
Empire District Electric Company	14,005	13,930	13,895	14,084	13,027	13,449	13,654	13,490
Kansas City Power & Light	10,746	11,166	10,902	10,921	10,004	10,456	10,557	10,048
KCP&L Greater Missouri Operations	12,983	13,377	12,892	13,042	12,066	12,433	12,463	11,927
Union Electric Co	13,380	13,874	12,819	13,502	12,397	12,147	12,665	12,313
Average (with Empire)	**12,779**	**13,087**	**12,627**	**12,887**	**11,873**	**12,121**	**12,335**	**11,944**
Average (without Empire)	**12,370**	**12,805**	**12,204**	**12,488**	**11,489**	**11,678**	**11,895**	**11,429**

Notes:
[1] Aquila became KCP&L Greater Missouri Operations beginning with 2008 data

Source: (EIA-f 2010)

Table 28. Historical Missouri Average Retail Electric Rates by Sector (2000-2008)

Year	Residential	Commercial	Industrial	Transportation	All Sectors
2008	$8.00	$6.61	$4.92	$5.40	$6.84
2007	$7.69	$6.34	$4.76	$6.16	$6.56
2006	$7.44	$6.08	$4.58	$5.75	$6.30
2005	$7.08	$5.92	$4.54	$4.77	$6.13
2004	$6.97	$5.80	$4.62	$4.91	$6.07
2003	$6.96	$5.78	$4.49	NA	$6.02
2002	$7.06	$5.88	$4.42	NA	$6.09
2001	$7.00	$5.89	$4.39	NA	$6.03
2000	$7.04	$5.83	$4.43	NA	$6.02

Source: (EIA-e 2010)

Table 29. Missouri AC Energy Estimates and Calculated Busbar Costs

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
1	36.436	-93.540	1,385	$423.65
2	36.792	-93.647	1,365	$429.85
3	37.149	-93.756	1,388	$422.73
4	37.507	-93.867	1,407	$417.02
5	37.866	-93.979	1,401	$418.81
6	38.226	-94.094	1,333	$440.17
7	38.587	-94.210	1,334	$439.84
8	38.948	-94.328	1,374	$427.04
9	39.311	-94.448	1,376	$426.42
10	39.675	-94.569	1,350	$434.63
11	40.039	-94.693	1,374	$427.04
12	40.404	-94.819	1,405	$417.62
13	40.770	-94.948	1,389	$422.43
14	36.349	-93.981	1,376	$426.42
15	36.704	-94.092	1,361	$431.12
16	37.060	-94.204	1,350	$434.63
17	37.417	-94.318	1,349	$434.95
18	37.775	-94.434	1,455	$403.26
19	38.134	-94.551	1,375	$426.73
20	38.494	-94.671	1,372	$427.66
21	38.854	-94.792	1,382	$424.57
22	39.216	-94.916	1,430	$410.31
23	39.578	-95.041	1,376	$426.42
24	39.942	-95.169	1,356	$432.71
25	40.306	-95.299	1,358	$432.07
26	40.710	-95.430	1,339	$438.20
27	36.259	-94.421	1,442	$406.90
28	36.613	-94.534	1,411	$415.84
29	36.520	-94.975	1,472	$398.61
30	36.968	-94.650	1,352	$433.99
31	37.325	-94.767	1,430	$410.31
32	37.681	-94.886	1,364	$430.17
33	38.039	-95.007	1,451	$404.38
34	38.398	-95.130	1,409	$416.43
35	38.758	-95.255	1,376	$426.42
36	39.118	-95.382	1,368	$428.91
37	39.480	-95.511	1,366	$429.54
38	39.842	-95.642	1,357	$432.39
39	40.205	-95.776	1,377	$426.11
40	40.569	-95.911	1,455	$403.26
41	36.398	-91.666	1,389	$422.43
42	36.757	-91.759	1,367	$429.22
43	37.116	-94.853	1,347	$435.60
44	37.477	-91.949	1,344	$436.57

Table 29. Missouri AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy	Busbar Cost
	Latitude	Longitude	(kWh)	(2010$/MWh)
45	37.839	-92.046	1,370	$428.28
46	38.201	-92.144	1,397	$420.01
47	38.565	-92.245	1,335	$439.51
48	38.930	-92.346	1,381	$424.87
49	39.295	-92.450	1,471	$398.88
50	39.662	-92.555	1,410	$416.13
51	40.029	-92.662	1,359	$431.75
52	40.398	-92.771	1,415	$414.66
53	40.767	-92.882	1,387	$423.03
54	36.323	-92.111	1,368	$428.91
55	36.681	-92.207	1,445	$406.05
56	37.039	-92.304	1,401	$418.81
57	37.399	-92.403	1,343	$436.89
58	37.760	-92.503	1,388	$422.73
59	38.122	-92.606	1,464	$400.79
60	38.485	-92.709	1,364	$430.17
61	38.848	-92.815	1,332	$440.50
62	39.213	-92.922	1,392	$421.52
63	39.578	-93.031	1,471	$398.88
64	39.945	-93.142	1,417	$414.08
65	40.312	-93.255	1,387	$423.03
66	40.681	-93.369	1,336	$439.18
67	36.245	-92.553	1,340	$437.87
68	36.602	-92.653	1,399	$419.41
69	36.960	-92.753	1,386	$423.34
70	37.319	-92.856	1,345	$436.24
71	37.678	-92.960	1,390	$422.12
72	38.039	-93.065	1,380	$425.18
73	38.401	-93.173	1,330	$441.16
74	38.764	-93.282	1,340	$437.87
75	39.128	-93.393	1,324	$443.16
76	39.492	-93.505	1,421	$412.91
77	39.858	-93.620	1,408	$416.73
78	40.224	-93.736	1,333	$440.17
79	40.592	-93.855	1,327	$442.16
80	39.164	-92.995	1,343	$436.89
81	36.520	-93.097	1,344	$436.57
82	36.877	-93.201	1,347	$435.60
83	37.235	-93.307	1,343	$436.89
84	37.594	-93.414	1,337	$438.86
85	37.954	-93.523	1,386	$423.34
86	38.315	-93.634	1,403	$418.21
87	38.677	-93.747	1,368	$428.91
88	39.039	-93.861	1,377	$426.11

Table 29. Missouri AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
89	39.403	-93.977	1,373	$427.35
90	39.768	-94.096	1,363	$430.48
91	40.133	-94.216	1,412	$415.54
92	40.499	-94.338	1,335	$439.51
93	36.792	-88.937	1,307	$448.93
94	37.155	-89.045	1,337	$438.86
95	36.372	-89.350	1,329	$441.50
96	36.733	-89.425	1,315	$446.20
97	37.096	-89.500	1,302	$450.65
98	37.459	-89.577	1,337	$438.86
99	37.824	-89.655	1,303	$450.31
100	38.189	-89.734	1,315	$446.20
101	35.952	-89.721	1,331	$440.83
102	36.311	-89.798	1,342	$437.22
103	36.672	-89.876	1,377	$426.11
104	37.033	-89.955	1,314	$446.54
105	37.760	-90.116	1,359	$431.75
106	38.125	-90.199	1,348	$435.27
107	38.491	-90.284	1,303	$450.31
108	38.858	-90.369	1,302	$450.65
109	39.226	-90.456	1,346	$435.92
110	35.889	-90.164	1,377	$426.11
111	36.248	-90.244	1,395	$420.61
112	36.607	-90.325	1,450	$404.65
113	36.968	-90.408	1,368	$428.91
114	37.330	-90.491	1,427	$411.18
115	37.694	-90.577	1,438	$408.03
116	38.058	-90.663	1,357	$432.39
117	38.423	-90.751	1,303	$450.31
118	38.789	-90.840	1,356	$432.71
119	39.156	-90.931	1,360	$431.43
120	39.524	-91.023	1,301	$451.00
121	39.893	-91.117	1,296	$452.74
122	40.263	-91.213	1,293	$453.79
123	40.635	-91.310	1,281	$458.04
124	36.181	-90.689	1,334	$439.84
125	36.540	-90.774	1,382	$424.57
126	36.901	-90.859	1,433	$409.46
127	37.262	-90.947	1,426	$411.47
128	37.624	-91.035	1,362	$430.80
129	37.988	-91.125	1,311	$447.56
130	38.352	-91.217	1,368	$428.91
131	38.717	-91.310	1,321	$444.17
132	39.084	-91.404	1,380	$425.18

Table 29. Missouri AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
133	39.451	-91.501	1,376	$426.42
134	39.819	-91.598	1,294	$453.44
135	40.188	-91.698	1,347	$435.60
136	40.559	-91.799	1,287	$455.90
137	40.930	-91.902	1,287	$455.90
138	36.471	-91.221	1,380	$425.18
139	36.830	-91.310	1,413	$415.25
140	37.191	-91.401	1,368	$428.91
141	37.552	-91.493	1,356	$432.71
142	37.915	-91.586	1,323	$443.50
143	38.278	-91.681	1,362	$430.80
144	38.643	-91.778	1,332	$440.50
145	39.008	-91.876	1,336	$439.18
146	39.374	-91.976	1,419	$413.49
147	39.742	-92.078	1,355	$433.03
148	40.110	-92.181	1,352	$433.99
149	40.480	-92.286	1,359	$431.75
150	40.850	-92.393	1,290	$454.84

Note: AC energy estimate based on 1-kW fixed-tilt PV system at latitude tilt and 0.8 derate factor

AC Energy Source: (NREL-b 2010)

Table 30. Missouri Case Study Solar PV Premium Calculation

Description	Cost
Average Price of Fixed-Axis Solar PV in Missouri [1]	$426.42
Average Price of Single-Axis Tracking PV in Missouri [1]	$368.06
Blended Rate for Missouri PV	$397.24
Average Price of Wind Energy in Missouri	$94.48
PV Premium in Missouri (2010$/MWh) [1]	**$302.76**

Note: [1] Based on results from Investigation 2 in this study

Table 31. Missouri Case Study Residential Rate Impacts Detailed Calculations

Year	Solar Carve-Out (%)	IOU Annual Electric Sales (MWh)	Solar Generation Required to Meet Carve-Out (MWh)	RPS Net Annual Solar Generation (MWh)	Annual Cost to Meet RPS Generation (2010$)	IOU Annual Residential Customers (Qty)	Annual Residential Rate Impact per Customer (2010$)	Annual Residential Rate Impact per Customer (2010$/kWh)	Annual Residential Rate Impact per Customer (2010¢/kWh)	Projected Retail Residential Electric Rate (2010¢/kWh)	Average Annual Customer Bill (2010$)	Rate Impact (%)
Formula	*A*	*B*	*C* *= A * B*	*D* *= C_2 - C_1*	*E* *= D * Solar Premium*	*F*	*G* *= E / F*	*H* *= G / Usage*	*I* *= H * 100*	*J*	*K* *= J / 100 * Usage*	*L* *= G / K*
Note(s)	[1]	[2] [3]		[4]	[5]	[6] [7]		[8]		[9] [10]	[11]	
2008		54,860,899				1,550,409				$ 8.00	$ 990	
2009		56,303,611				1,566,385				$ 8.14	$ 1,006	
2010		57,784,262				1,582,527				$ 8.28	$ 1,024	
2011	0.04%	59,303,852	23,722	23,722	$ 7,181,944	1,598,834	$ 4.49	$ 0.00036	$ 0.03631	$ 8.42	$ 1,041	0.43%
2012	0.04%	60,863,403	24,345	624	$ 188,868	1,615,309	$ 0.12	$ 0.00001	$ 0.00095	$ 8.56	$ 1,059	0.01%
2013	0.04%	62,463,966	24,986	640	$ 193,835	1,631,955	$ 0.12	$ 0.00001	$ 0.00096	$ 8.71	$ 1,077	0.01%
2014	0.10%	64,106,621	64,107	39,121	$ 11,844,301	1,648,771	$ 7.18	$ 0.00058	$ 0.05808	$ 8.85	$ 1,095	0.66%
2015	0.10%	65,792,473	65,792	1,686	$ 510,409	1,665,762	$ 0.31	$ 0.00002	$ 0.00248	$ 9.00	$ 1,114	0.03%
2016	0.10%	67,522,659	67,523	1,730	$ 523,832	1,682,927	$ 0.31	$ 0.00003	$ 0.00252	$ 9.16	$ 1,133	0.03%
2017	0.10%	69,298,345	69,298	1,776	$ 537,607	1,700,269	$ 0.32	$ 0.00003	$ 0.00256	$ 9.31	$ 1,152	0.03%
2018	0.20%	71,120,728	142,241	72,943	$ 22,084,286	1,717,789	$ 12.86	$ 0.00104	$ 0.10393	$ 9.47	$ 1,172	1.10%
2019	0.20%	72,991,035	145,982	3,741	$ 1,132,510	1,735,491	$ 0.65	$ 0.00005	$ 0.00528	$ 9.63	$ 1,192	0.05%
2020	0.20%	74,910,526	149,821	3,839	$ 1,162,292	1,753,374	$ 0.66	$ 0.00005	$ 0.00536	$ 9.80	$ 1,212	0.05%
2021	0.30%	76,880,495	230,641	80,820	$ 24,469,228	1,771,442	$ 13.81	$ 0.00112	$ 0.11167	$ 9.97	$ 1,233	1.12%
Total				**230,641**	**$ 69,829,113**	**18,521,923**						**0.32%**

Notes:

[1] Based on 2.0% of annual RPS total for investor-owned utilities

[2] 2008 annual electric sales based on actual totals from KCP&L, KCP&L Greater Missouri Operations, and Union Electric. Empire excluded from evaluation.

[3] Annual electric sales escalated based on historical (2001-2008) electric sales data from state IOUs, or approximately 2.63%. Empire excluded from evaluation.

[4] Represents annual increase in solar generation to remain in compliance with RPS. Assumes all generation built in first year (2011) and incremental generation built thereafter to remain compliant.

[5] Represents total cost to meet RPS generation requirements in column D. Solar premium of $302.76 based upon results of Investigation 2 in this study and as detailed in previous table.

[6] 2008 annual residential electric customers based on actual totals from KCP&L, KCP&L Greater Missouri Operations, and Union Electric. Empire excluded from evaluation.

[7] Annual retail electric customers escalated based on historical (2001-2008) data from state IOUs, or approximately 1.03%. Empire excluded from evaluation.

[8] Represents estimated annual rate impact on residential customers. Annual usage of 12,370 kWh/person based upon historic data (2001-2008) from Missouri IOUs. Empire excluded from evaluation.

[9] 2008 retail electric rate based on actual totals from KCP&L, KCP&L Greater Missouri Operations, and Union Electric. Empire excluded from evaluation.

[10] Annual retail electric rates escalated based on historical (2001-2008) data from state IOUs, or approximately 1.70%. Empire excluded from evaluation.

[11] Represents average annual residential customer electric bill. Annual usage of 12,370 kWh/person based upon historic data (2001-2008) from Missouri IOUs. Empire excluded from evaluation.

Table 32. Missouri Case Study Life Cycle Analysis Detailed Calculations

Assumptions	**Row**	***Formula***	**Notes**	**Solar**	**Wind**	**Differential**
Carbon Footprint (grams CO_2e/kWh)	*A*		[1] [2]	52.00	4.64	47.36
Meeting the RPS in Missouri				**Solar**	**Wind**	**Differential**
Total Generation to Meet Ultimate RPS in 2021 (MWh)	*B*		[3]	230,641	230,641	
Total Generation to Meet Ultimate RPS in 2021 (kWh)	*C*	***= B * 1000***		230,641,486	230,641,486	
Carbon Emissions from Meeting RPS				**Solar**	**Wind**	**Differential**
Lifetime Carbon Emissions from Meeting RPS (grams CO_2e)	*D*	***= A * C***	[4]	11,993,357,295	1,070,176,497	10,923,180,798
Lifetime Carbon Emissions from Meeting RPS (pounds CO_2e)	*E*	***= D * 0.0022***		26,440,827	2,359,335	24,081,491
Lifetime Carbon Emissions from Meeting RPS (tons CO_2e)	*F*	***= E / 2000***		13,220	1,180	12,041
Carbon Emissions from Meeting RPS - Comparison to Coal				**Solar**	**Wind**	**Differential**
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (tons)	*G*	***= (F * 1MM) / (206 x 8400)***	[5]	7,640	682	6,958
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (ft^3)	*H*	***= (G * 2000) / 1000***	[6]			13,917
Months of Equivalent Coal Plant Operations	*I*	***= (G / 329783) * 12***	[7]			0.3
Carbon Emissions from Meeting RPS - Comparison to Gasoline				**Solar**	**Wind**	**Differential**
Equivalent Qty of Gasoline Burned to LC Emissions Meeting RPS (Gallons)	*J*	***= E / 19.4***	[8] [9]	1,362,929	121,615	1,241,314
Additional Cars on Road Based on Equivalent Emissions	*K*	***= J / 450***	[10] [11]	3,029	270	2,758
Carbon Emissions from Meeting RPS - Comparison to Deforestation				**Solar**	**Wind**	**Differential**
Equivalent Deforestation Rate to Meeting RPS (Acres)	*L*	***= F / (1 * (2204 / 2000))***	[12] [13]			10,926

Notes:

[1] Source: National Resource Council. *Electricity from Renewable Resources: Status, Prospects, and Impediments.* Washington D.C.: National Academies Press, 2010.

[2] Solar value (52) represents multi-crystalline silicon PV. Wind value (4.64) adapted from study performed by Vestas.

[3] Based on results from Investigation 3 of this study.

[4] Represents equivalent carbon dioxide emissions from satisfying solar carve-out objectives in state RPS.

[5] Represents equivalent tons of coal from using solar instead of wind to satisfy solar carve-out objectives in state RPS. Based on 206 lb/MMBtu CO_2 emissions rate and 8400 Btu/lb heat content.

[6] Represents total volume of equivalent tons of coal in row G. Based on assumption of 1,000 lb/ft^3 for density of coal.

[7] Represents how many months a 50-MW coal plant with an 8,600 Btu/kWh (HHV) heat rate and 85% net annual capacity factor (which would burn 329,783 TPY) would operate to release equivalent emissions.

[8] Represents gallons of gasoline that could be burned and would release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[9] Assumes 19.4 pounds/gallons of CO2 in gasoline. Source: Environmental Protection Agency (http://www.epa.gov/OMS/climate/420f05004.htm)

[10] Represents the number of additional cars that would be on road and release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[11] Assumes annual per capita gasoline usage of 450 gallons. Source: Perry Management, Inc. (http://perrymanagement.com/092605_cheap_gas.html)

[12] Represents the equivalent deforestation of land (in acres) from satisfying solar carve-out requirements in state RPS>

[13] Assumes a typical acre of forested land can sequester one metric tonne of carbon dioxide annually. Source: Environmental Protection Agency (http://www.epa.gov/sequestration/faq.html).

Appendix H

Investigation 3 (State Case Studies) Detailed Tables for New Jersey Case Study

As part of the state case studies detailed in Section 6 of this report, numerous detailed datasets were utilized. The following is an overview of this data for the New Jersey case study. Note that unless stated otherwise, values shown

Table 33. Historical New Jersey Retail Electric Sales by Sector (2000-2008)

Year	Residential	Commercial	Industrial	Transportation	All Sectors
2008	29,111,023	40,569,713	10,537,289	301,518	80,519,543
2007	29,751,647	40,876,070	11,013,372	293,245	81,934,334
2006	28,621,556	39,437,464	11,330,599	291,328	79,680,947
2005	29,973,443	39,762,419	11,862,286	298,665	81,896,813
2004	28,020,125	38,073,559	11,209,578	289,905	77,593,167
2003	27,367,126	36,616,281	12,214,748	184,357	76,382,512
2002	27,171,374	35,429,281	11,475,853	NA	74,602,620
2001	25,491,423	34,445,279	12,706,552	NA	73,177,390
2000	24,547,336	33,112,343	11,811,562	NA	69,977,129

Source: (EIA-g 2010)

Table 34. Historical New Jersey Retail Customers by Sector (2000-2008)

Year	Residential	Commercial	Industrial	Transportation	All Sectors
2008	3,409,806	469,341	13,391	6	3,892,544
2007	3,394,474	465,987	13,579	7	3,874,047
2006	3,372,447	461,461	13,929	7	3,847,844
2005	3,341,396	455,286	13,666	6	3,810,354
2004	3,311,246	452,563	12,165	6	3,775,980
2003	3,259,242	449,061	14,205	3	3,722,511
2002	3,250,958	429,278	13,334	0	3,704,450
2001	3,213,276	423,431	12,687	0	3,660,287
2000	3,185,052	432,580	12,463	0	3,640,522

Source: (EIA-h 2010)

Table 35. Historical New Jersey Average Retail Electric Rates by Sector (2000-2008)

Year	Residential	Commercial	Industrial	Transportation	All Sectors
2008	$15.66	$14.48	$10.86	$15.98	$14.44
2007	$14.14	$12.99	$10.08	$11.14	$13.01
2006	$12.84	$11.62	$10.42	$9.70	$11.88
2005	$11.74	$10.61	$9.76	$7.65	$10.89
2004	$11.23	$9.96	$9.03	$10.94	$10.29
2003	$10.67	$9.11	$7.99	$7.15	$9.48
2002	$10.38	$8.90	$7.72	NA	$9.30
2001	$10.21	$9.09	$8.33	NA	$9.36
2000	$10.27	$9.14	$8.58	NA	$9.47

Source: (EIA-e 2010)

Table 36. New Jersey AC Energy Estimates and Calculated Busbar Costs

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
1	41.329	-75.173	1,225	$478.98
2	40.950	-75.215	1,248	$470.15
3	40.572	-75.257	1,227	$478.20
4	40.195	-75.298	1,298	$452.04
5	39.819	-75.338	1,285	$456.61
6	39.444	-75.378	1,265	$463.83
7	39.071	-75.416	1,275	$460.20
8	41.295	-74.668	1,162	$504.95
9	40.917	-74.715	1,301	$451.00
10	40.539	-74.760	1,297	$452.39
11	40.162	-74.806	1,226	$478.59
12	39.787	-74.850	1,249	$469.78
13	39.413	-74.894	1,361	$431.12
14	39.039	-74.936	1,240	$473.18
15	41.258	-74.163	1,250	$469.40
16	40.880	-74.214	1,275	$460.20
17	40.503	-74.265	1,239	$473.57
18	40.127	-74.314	1,306	$449.27
19	39.752	-74.362	1,241	$472.80
20	39.378	-74.410	1,287	$455.90
21	41.218	-73.660	1,243	$472.04
22	40.840	-73.715	1,246	$470.91
23	40.463	-73.770	1,182	$496.40
24	40.088	-73.823	1,214	$483.32
25	38.667	-74.979	1,246	$470.91
26	38.699	-75.455	1,305	$449.62
27	38.727	-75.931	1,286	$456.26
28	39.099	-75.897	1,298	$452.04
29	39.473	-75.862	1,282	$457.68
30	39.848	-75.827	1,278	$459.12
31	40.224	-75.791	1,236	$474.72
32	40.602	-75.754	1,290	$454.84
33	40.980	-75.717	1,159	$506.25
34	41.360	-75.679	1,160	$505.82
35	41.675	-74.620	1,152	$509.33
36	41.638	-74.111	1,249	$469.78
37	41.709	-75.130	1,153	$508.89
38	41.740	-75.641	1,127	$520.63

Note: AC energy estimate based on 1-kW fixed-tilt PV system at latitude tilt and 0.8 derate factor

AC Energy Source: (NREL-b 2010)

Table 37. New Jersey Case Study Solar PV Premium Calculation

Description	Cost
Average Price of Fixed-Axis Solar PV in New Jersey [1]	$478.59
Average Price of Single-Axis Tracking PV in New Jersey [1]	$420.92
Blended Rate for New Jersey PV	$449.75
Average Price of Wind Energy in New Jersey	$99.46
PV Premium in New Jersey (2010$/MWh) [1]	**$350.29**

Note: [1] Based on results from Investigation 2 in this study

Table 38. New Jersey Case Study Residential Rate Impacts Detailed Calculations

Year	Solar Generation Required to Meet Carve-Out (MWh)	RPS Net Annual Solar Generation (MWh)	Annual Cost to Meet RPS Generation (2010$)	Annual Retail Residential Customers (Qty)	Annual Residential Rate Impact per Customer (2010$)	Annual Residential Rate Impact per Customer (2010$/kWh)	Annual Residential Rate Impact per Customer (2010¢/kWh)	Projected Retail Residential Electric Rate (¢/kWh)	Average Annual Customer Bill (2010$)	Rate Impact (%)
Formula	***A***	***B*** *= C_2 - C_1*	***C*** *= B * Solar Premium*	***D***	***E*** *= C / D*	***F*** *= E / Usage*	***G*** *= F * 100*	***H***	***I*** *= H / 100 * Usage*	***J*** *= E / I*
Note(s)	**[1]**	**[2]**	**[3]**	**[4] [5]**		**[6]**		**[7] [8]**		
2008				3,409,806				$ 15.66	$ 1,316	
2009				3,439,883				$ 16.69	$ 1,402	
2010				3,470,225				$ 17.78	$ 1,494	
2011	306,000	306,000	$ 107,189,200	3,500,834	$ 30.62	$ 0.0036	$ 0.36442	$ 18.95	$ 1,592	1.92%
2012	442,000	136,000	$ 47,639,645	3,531,714	$ 13.49	$ 0.0016	$ 0.16055	$ 20.19	$ 1,696	0.80%
2013	596,000	154,000	$ 53,944,892	3,562,866	$ 15.14	$ 0.0018	$ 0.18021	$ 21.52	$ 1,808	0.84%
2014	772,000	176,000	$ 61,651,305	3,594,293	$ 17.15	$ 0.0020	$ 0.20415	$ 22.93	$ 1,926	0.89%
2015	965,000	193,000	$ 67,606,260	3,625,997	$ 18.64	$ 0.0022	$ 0.22191	$ 24.43	$ 2,053	0.91%
2016	1,150,000	185,000	$ 64,803,928	3,657,981	$ 17.72	$ 0.0021	$ 0.21086	$ 26.03	$ 2,187	0.81%
2017	1,357,000	207,000	$ 72,510,341	3,690,246	$ 19.65	$ 0.0023	$ 0.23387	$ 27.74	$ 2,331	0.84%
2018	1,591,000	234,000	$ 81,968,212	3,722,797	$ 22.02	$ 0.0026	$ 0.26206	$ 29.56	$ 2,484	0.89%
2019	1,858,000	267,000	$ 93,527,832	3,755,634	$ 24.90	$ 0.0030	$ 0.29640	$ 31.50	$ 2,647	0.94%
2020	2,164,000	306,000	$ 107,189,200	3,788,761	$ 28.29	$ 0.0034	$ 0.33673	$ 33.57	$ 2,820	1.00%
2021	2,518,000	354,000	$ 124,003,192	3,822,181	$ 32.44	$ 0.0039	$ 0.38614	$ 35.77	$ 3,005	1.08%
2022	2,928,000	410,000	$ 143,619,517	3,855,895	$ 37.25	$ 0.0044	$ 0.44332	$ 38.12	$ 3,203	1.16%
2023	3,433,000	505,000	$ 176,897,209	3,889,907	$ 45.48	$ 0.0054	$ 0.54126	$ 40.62	$ 3,413	1.33%
2024	3,989,000	556,000	$ 194,762,076	3,924,218	$ 49.63	$ 0.0059	$ 0.59071	$ 43.28	$ 3,637	1.36%
2025	4,610,000	621,000	$ 217,531,024	3,958,832	$ 54.95	$ 0.0065	$ 0.65400	$ 46.12	$ 3,875	1.42%
2026	5,316,000	706,000	$ 247,305,802	3,993,752	$ 61.92	$ 0.0074	$ 0.73702	$ 49.15	$ 4,129	1.50%
Total		**5,316,000**	**$ 1,862,149,634**	**59,875,909**						**1.11%**

Notes:

[1] Based on carve-out requirements in current New Jersey RPS. These values outlined as energy (MWh), not percentage.

[2] Represents annual increase in solar generation to remain in compliance with RPS. Assumes all generation built in first year (2011) and incremental generation built thereafter to remain compliant.

[3] Represents total cost to meet RPS generation requirements in column C. Solar premium of $350.29 based upon results of Investigation 2 in this study and as detailed in previous table.

[4] 2008 annual retail electric residential customers based upon actual data from EIA for New Jersey.

[5] Annual retail electric customers escalated based on historical (2000-2008) data from EIA, or approximately 0.88%.

[6] Represents estimated annual rate impact on residential customers. Annual usage of 8,402 kWh/person based upon historic data (2000-2008) from New Jersey / EIA.

[7] 2008 retail electric rates based on actual data from state of New Jersey and EIA.

[8] Annual retail electric rates escalated based on historical (2000-2008) data from state of New Jersey and EIA, or approximately 6.56%.

[9] Represents average annual residential customer electric bill. Annual usage of 8,402 kWh/person based upon historic data (2000-2008) from New Jersey and EIA.

Table 39. New Jersey Case Study Life Cycle Analysis Detailed Calculations

Assumptions	**Row**	***Formula***	**Notes**	**Solar**	**Wind**	**Differential**
Carbon Footprint (grams CO_2e/kWh)	***A***		[1] [2]	52.00	4.64	47.36
Meeting the RPS in Missouri				**Solar**	**Wind**	**Differential**
Total Generation to Meet Ultimate RPS in 2021 (MWh)	***B***		[3]	5,316,000	5,316,000	
Total Generation to Meet Ultimate RPS in 2021 (kWh)	***C***	***= B * 1000***		5,316,000,000	5,316,000,000	
Carbon Emissions from Meeting RPS				**Solar**	**Wind**	**Differential**
Lifetime Carbon Emissions from Meeting RPS (grams CO_2e)	***D***	***= A * C***	[4]	276,432,000,000	24,666,240,000	251,765,760,000
Lifetime Carbon Emissions from Meeting RPS (pounds CO_2e)	***E***	***= D * 0.0022***		609,428,240	54,379,751	555,048,489
Lifetime Carbon Emissions from Meeting RPS (tons CO_2e)	***F***	***= E / 2000***		304,714	27,190	277,524
Carbon Emissions from Meeting RPS - Comparison to Coal				**Solar**	**Wind**	**Differential**
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (tons)	***G***	***= (F * 1MM) / (206 x 8400)***	[5]	176,095	15,713	160,382
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (ft^3)	***H***	***= (G * 2000) / 1000***	[6]			320,763
Months of Equivalent Coal Plant Operations	***I***	***= (G / 329783) * 12***	[7]			5.8
Carbon Emissions from Meeting RPS - Comparison to Gasoline				**Solar**	**Wind**	**Differential**
Equivalent Qty of Gasoline Burned to LC Emissions Meeting RPS (Gallons)	***J***	***= E / 19.4***	[8] [9]	31,413,827	2,803,080	28,610,747
Additional Cars on Road Based on Equivalent Emissions	***K***	***= J / 450***	[10] [11]	69,809	6,229	63,579
Carbon Emissions from Meeting RPS - Comparison to Deforestation				**Solar**	**Wind**	**Differential**
Equivalent Deforestation Rate to Meeting RPS (Acres)	***L***	***= F / (1 * (2204 / 2000))***	[12] [13]			251,837

Notes:

[1] Source: National Resource Council. *Electricity from Renewable Resources: Status, Prospects, and Impediments.* Washington D.C.: National Academies Press, 2010.

[2] Solar value (52) represents multi-crystalline silicon PV. Wind value (4.64) adapted from study performed by Vestas.

[3] Based on results from Investigation 3 of this study.

[4] Represents equivalent carbon dioxide emissions from satisfying solar carve-out objectives in state RPS.

[5] Represents equivalent tons of coal from using solar instead of wind to satisfy solar carve-out objectives in state RPS. Based on 206 lb/MMBtu CO_2 emissions rate and 8400 Btu/lb heat content.

[6] Represents total volume of equivalent tons of coal in row G. Based on assumption of 1,000 lb/ft^3 for density of coal.

[7] Represents how many months a 50-MW coal plant with an 8,600 Btu/kWh (HHV) heat rate and 85% net annual capacity factor (which would burn 329,783 TPY) would operate to release equivalent emissions.

[8] Represents gallons of gasoline that could be burned and would release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[9] Assumes 19.4 pounds/gallons of CO2 in gasoline. Source: Environmental Protection Agency (http://www.epa.gov/OMS/climate/420f05004.htm)

[10] Represents the number of additional cars that would be on road and release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[11] Assumes annual per capita gasoline usage of 450 gallons. Source: Perry Management, Inc. (http://perrymanagement.com/092605_cheap_gas.html)

[12] Represents the equivalent deforestation of land (in acres) from satisfying solar carve-out requirements in state RPS>

[13] Assumes a typical acre of forested land can sequester one metric tonne of carbon dioxide annually. Source: Environmental Protection Agency (http://www.epa.gov/sequestration/faq.html).

Appendix I

Investigation 3 (State Case Studies) Detailed Tables for New Mexico Case Study

As part of the state case studies detailed in Section 6 of this report, numerous detailed datasets were utilized. The following is an overview of this data for the New Mexico case study.

Table 40. Historical New Mexico Electric Sales, Customers, and Usage (2001-2008)

	Total Electric Sales in New Mexico (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
El Paso Electric Company	1,598,578	1,593,747	1,543,723	1,503,364	1,441,872	1,407,577	1,355,007	1,304,178
Public Service Co of NM	9,162,355	9,371,704	7,957,531	7,685,294	7,471,491	7,352,711	7,406,506	7,255,297
Southwestern Public Service Co	4,138,056	4,106,037	3,883,263	3,719,446	3,535,278	3,413,502	3,443,168	3,418,034
Totals	**13,300,411**	**13,477,741**	**11,840,794**	**11,404,740**	**11,006,769**	**10,766,213**	**10,849,674**	**10,673,331**

	Total Residential Electric Sales in New Mexico (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
El Paso Electric Company	589,696	592,148	554,500	541,201	509,344	492,939	471,917	447,398
Public Service Co of NM	3,214,333	3,210,651	2,754,614	2,661,485	2,498,339	2,397,946	2,305,731	2,197,889
Southwestern Public Service Co	978,810	979,448	911,241	905,589	894,457	864,732	876,348	840,291
Totals	**4,193,143**	**4,190,099**	**3,665,855**	**3,567,074**	**3,392,796**	**3,262,678**	**3,182,079**	**3,038,180**

	Total Electric Customers in New Mexico (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
El Paso Electric Company	87,849	86,210	83,501	81,237	78,005	75,304	73,428	71,734
Public Service Co of NM	495,284	489,410	430,211	417,986	406,968	396,303	384,478	377,589
Southwestern Public Service Co	111,537	109,657	108,064	106,515	107,214	105,479	105,040	104,719
Totals	**694,670**	**685,277**	**621,776**	**605,738**	**592,187**	**577,086**	**562,946**	**554,042**

	Total Residential Electric Customers in New Mexico (MWh)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
El Paso Electric Company	77,635	76,037	73,447	71,504	68,641	66,280	64,701	63,281
Public Service Co of NM	440,935	435,561	383,680	372,703	362,721	353,255	342,521	336,614
Southwestern Public Service Co	89,426	87,667	86,574	85,529	86,203	84,705	84,607	84,545
Totals	**530,361**	**523,228**	**470,254**	**458,232**	**448,924**	**437,960**	**427,128**	**421,159**

	Average Annual Residential Customer Usage in New Mexico (kWh/person/year)							
Investor-Owned Utility	**2008**	**2007**	**2006**	**2005**	**2004**	**2003**	**2002**	**2001**
El Paso Electric Company	7,596	7,788	7,550	7,569	7,420	7,437	7,294	7,070
Public Service Co of NM	7,290	7,371	7,179	7,141	6,888	6,788	6,732	6,529
Southwestern Public Service Co	10,945	11,172	10,526	10,588	10,376	10,209	10,358	9,939
Average	**8,610**	**8,777**	**8,418**	**8,433**	**8,228**	**8,145**	**8,128**	**7,846**

Source: (EIA-f 2010)

Table 41. Historical New Mexico Average Retail Electric Rates by Sector (2000-2008)

Year	Residential	Commercial	Industrial	Transportation	All Sectors
2008	$10.01	$8.67	$6.38	NA	$8.35
2007	$9.12	$7.66	$5.60	NA	$7.44
2006	$9.06	$7.61	$5.57	NA	$7.37
2005	$9.13	$7.81	$5.61	NA	$7.51
2004	$8.67	$7.39	$5.22	NA	$7.10
2003	$8.69	$7.36	$4.95	NA	$7.00
2002	$8.50	$7.22	$4.48	NA	$6.73
2001	$8.74	$7.50	$5.45	NA	$7.16
2000	$8.36	$7.06	$4.69	NA	$6.58

Source: (EIA-e 2010)

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
1	31.827	-107.211	1,635	$358.87
2	32.139	-107.401	1,635	$358.87
3	32.451	-107.593	1,650	$355.61
4	32.764	-107.788	1,662	$353.04
5	33.077	-107.985	1,693	$346.57
6	33.390	-108.185	1,707	$343.73
7	33.704	-108.388	1,765	$332.44
8	34.018	-108.593	1,763	$332.81
9	34.333	-108.801	1,771	$331.31
10	34.647	-109.012	1,768	$331.87
11	34.962	-109.226	1,593	$368.33
12	31.666	-107.577	1,760	$333.38
13	31.976	-107.768	1,765	$332.44
14	32.287	-107.962	1,778	$330.01
15	32.598	-108.159	1,782	$329.26
16	32.910	-108.358	1,736	$337.99
17	33.221	-108.560	1,687	$347.81
18	33.534	-108.764	1,712	$342.73
19	33.846	-108.971	1,716	$341.93
20	34.159	-109.181	1,681	$349.05
21	31.503	-107.940	1,781	$329.45
22	31.812	-108.133	1,752	$334.90
23	32.121	-108.329	1,779	$329.82
24	32.431	-108.527	1,766	$332.25
25	32.740	-108.728	1,741	$337.02
26	33.051	-108.931	1,719	$341.33
27	33.361	-109.137	1,699	$345.35
28	31.338	-108.301	1,749	$335.48
29	31.646	-108.496	1,627	$360.63
30	31.953	-108.693	1,757	$333.95
31	32.261	-108.893	1,735	$338.18
32	32.570	-109.095	1,730	$339.16
33	31.172	-108.659	1,633	$359.31
34	31.478	-108.856	1,630	$359.97
35	31.784	-109.055	1,637	$358.43
36	31.308	-109.213	1,632	$359.53
37	31.202	-105.927	1,661	$353.25
38	31.515	-106.107	1,652	$355.18
39	31.829	-106.288	1,658	$353.89
40	32.144	-106.472	1,662	$353.04
41	32.459	-106.659	1,669	$351.56
42	32.774	-106.847	1,684	$348.43
43	33.090	-107.039	1,681	$349.05
44	33.406	-107.232	1,714	$342.33

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
45	33.723	-107.429	1,710	$343.13
46	34.040	-107.628	1,781	$329.45
47	34.357	-107.829	1,780	$329.63
48	34.675	-108.034	1,653	$354.96
49	34.993	-108.241	1,618	$362.64
50	35.311	-108.451	1,601	$366.49
51	35.630	-108.664	1,589	$369.26
52	35.949	-108.880	1,578	$371.83
53	36.268	-109.099	1,718	$341.53
54	31.673	-106.657	1,658	$353.89
55	31.986	-106.843	1,678	$349.67
56	32.300	-107.310	1,636	$358.65
57	32.614	-107.221	1,663	$352.83
58	32.928	-107.415	1,675	$350.30
59	33.243	-107.610	1,693	$346.57
60	33.558	-107.808	1,764	$332.62
61	33.873	-108.009	1,786	$328.53
62	34.189	-108.213	1,778	$330.01
63	34.505	-108.419	1,761	$333.19
64	34.821	-108.628	1,613	$363.76
65	35.138	-108.840	1,581	$371.13
66	35.455	-109.055	1,583	$370.66
67	31.968	-104.992	1,748	$335.67
68	32.287	-105.168	1,744	$336.44
69	32.606	-105.346	1,645	$356.69
70	32.925	-105.527	1,638	$358.21
71	33.245	-105.710	1,641	$357.56
72	33.566	-105.896	1,655	$354.53
73	33.886	-106.084	1,695	$346.16
74	34.208	-106.274	1,727	$339.75
75	34.529	-106.467	1,625	$361.08
76	34.852	-106.663	1,623	$361.52
77	35.174	-106.862	1,620	$362.19
78	35.497	-107.063	1,699	$345.35
79	35.820	-107.267	1,741	$337.02
80	36.144	-107.474	1,598	$367.18
81	36.468	-107.684	1,587	$369.72
82	36.792	-107.897	1,559	$376.36
83	37.116	-108.113	1,548	$379.04
84	31.819	-105.366	1,667	$351.98
85	32.136	-105.544	1,664	$352.61
86	32.454	-105.724	1,647	$356.25
87	32.772	-105.907	1,616	$363.09
88	33.090	-106.092	1,615	$363.31

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
89	33.409	-106.279	1,648	$356.04
90	33.728	-106.469	1,740	$337.21
91	34.048	-106.662	1,741	$337.02
92	34.368	-106.857	1,738	$337.60
93	34.689	-107.055	1,617	$362.86
94	35.010	-107.255	1,723	$340.54
95	35.331	-107.459	1,687	$347.81
96	35.653	-107.665	1,645	$356.69
97	65.974	-107.874	1,793	$327.24
98	36.297	-108.086	1,591	$368.79
99	36.619	-108.301	1,557	$376.85
100	36.942	-108.519	1,540	$381.01
101	31.984	-105.917	1,672	$350.93
102	32.300	-106.099	1,647	$356.25
103	32.616	-106.284	1,628	$360.41
104	32.933	-106.471	1,635	$358.87
105	33.250	-106.660	1,685	$348.22
106	33.568	-106.852	1,694	$346.37
107	33.886	-107.047	1,731	$338.97
108	34.205	-107.244	1,765	$332.44
109	34.524	-107.443	1,732	$338.77
110	34.843	-107.646	1,722	$340.74
111	35.163	-107.851	1,642	$357.34
112	35.483	-108.059	1,602	$366.26
113	35.803	-108.270	1,590	$369.02
114	36.124	-108.484	1,805	$325.07
115	36.444	-108.701	1,598	$367.18
116	36.765	-108.921	1,586	$369.96
117	37.087	-109.144	1,630	$359.97
118	31.941	-104.067	1,592	$368.56
119	32.261	-104.267	1,583	$370.66
120	32.583	-104.409	1,643	$357.12
121	32.904	-104.584	1,598	$367.18
122	33.227	-104.760	1,643	$357.12
123	33.550	-104.939	1,630	$359.97
124	33.873	-105.121	1,600	$366.72
125	34.197	-105.305	1,676	$350.09
126	34.521	-105.492	1,722	$340.74
127	34.846	-105.681	1,637	$358.43
128	35.171	-105.872	1,631	$359.75
129	35.497	-106.067	1,619	$362.41
130	35.823	-106.264	1,625	$361.08
131	36.150	-106.464	1,631	$359.75
132	36.476	-106.667	1,737	$337.79

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
133	36.804	-106.873	1,639	$357.99
134	37.131	-107.081	1,620	$362.19
135	31.797	-104.444	1,710	$343.13
136	32.116	-104.616	1,616	$363.09
137	32.436	-104.790	1,735	$338.18
138	32.756	-104.966	1,659	$353.68
139	33.077	-105.145	1,627	$360.63
140	33.398	-105.326	1,649	$355.82
141	33.720	-105.509	1,636	$358.65
142	34.043	-105.696	1,622	$361.74
143	34.365	-105.884	1,624	$361.30
144	34.689	-106.075	1,632	$359.53
145	35.012	-106.269	1,635	$358.87
146	35.337	-106.466	1,637	$358.43
147	35.661	-106.665	1,655	$354.53
148	35.986	-106.867	1,701	$344.94
149	36.311	-107.072	1,651	$355.39
150	36.637	-107.280	1,606	$365.35
151	36.963	-107.491	1,590	$369.02
152	37.042	-102.957	1,585	$370.19
153	36.224	-103.020	1,588	$369.49
154	36.561	-103.199	1,694	$346.37
155	36.898	-103.380	1,585	$370.19
156	35.079	-102.909	1,600	$366.72
157	35.412	-103.082	1,603	$366.03
158	35.746	-103.257	1,589	$369.26
159	36.081	-103.436	1,696	$345.96
160	36.415	-103.616	1,584	$370.42
161	36.751	-103.800	1,557	$376.85
162	37.087	-103.986	1,567	$374.44
163	34.276	-102.971	1,582	$370.89
164	34.606	-103.141	1,640	$357.77
165	34.937	-103.314	1,610	$364.44
166	35.269	-103.490	1,601	$366.49
167	35.602	-103.668	1,613	$363.76
168	35.934	-103.848	1,587	$369.72
169	36.268	-104.031	1,769	$331.68
170	36.602	-104.217	1,562	$375.64
171	36.936	-104.406	1,581	$371.13
172	33.478	-103.030	1,719	$341.33
173	33.806	-103.199	1,613	$363.76
174	34.135	-103.369	1,586	$369.96
175	34.464	-103.542	1,647	$356.25
176	34.794	-103.717	1,616	$363.09

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
177	35.124	-103.895	1,609	$364.67
178	35.455	-104.076	1,570	$373.73
179	35.786	-104.258	1,577	$372.07
180	36.118	-104.444	1,596	$367.64
181	36.450	-104.632	1,716	$341.93
182	36.783	-104.823	1,579	$371.60
183	37.116	-105.017	1,615	$363.31
184	32.361	-102.925	1,599	$366.95
185	32.686	-103.088	1,593	$368.33
186	33.011	-103.254	1,613	$363.76
187	33.338	-103.422	1,682	$348.84
188	33.664	-103.593	1,734	$338.38
189	33.991	-103.765	1,609	$364.67
190	34.319	-103.940	1,718	$341.53
191	34.647	-104.118	1,619	$362.41
192	34.976	-104.298	1,574	$372.78
193	35.306	-104.481	1,572	$373.25
194	35.636	-104.666	1,585	$370.19
195	35.966	-104.854	1,605	$365.58
196	36.297	-105.044	1,638	$358.21
197	36.628	-105.238	1,615	$363.31
198	36.960	-105.434	1,645	$356.69
199	31.900	-103.144	1,685	$348.22
200	32.223	-103.308	1,635	$358.87
201	32.546	-103.474	1,637	$358.43
202	32.871	-103.641	1,684	$348.43
203	33.195	-103.812	1,612	$363.99
204	33.520	-103.984	1,626	$360.85
205	33.846	-104.159	1,713	$342.53
206	34.172	-104.336	1,747	$335.86
207	34.499	-104.516	1,674	$350.51
208	34.827	-104.698	1,716	$341.93
209	35.155	-104.883	1,580	$371.36
210	35.483	-105.071	1,598	$367.18
211	35.812	-105.261	1,604	$365.80
212	36.141	-105.454	1,620	$362.19
213	36.471	-105.649	1,627	$360.63
214	36.801	-105.848	1,633	$359.31
215	37.131	-106.049	1,665	$352.40
216	32.083	-103.689	1,563	$375.40
217	32.405	-103.857	1,573	$373.01
218	32.728	-104.027	1,627	$360.63
219	33.051	-104.199	1,591	$368.79
220	33.375	-104.373	1,611	$364.21

Table 42. New Mexico AC Energy Estimates and Calculated Busbar Costs (cont.)

No.	PVWatts Grid		AC Energy (kWh)	Busbar Cost (2010$/MWh)
	Latitude	Longitude		
221	33.699	-104.550	1,641	$357.56
222	32.024	-104.730	1,682	$348.84
223	34.349	-104.912	1,673	$350.72
224	34.675	-105.096	1,715	$342.13
225	35.001	-105.283	1,605	$365.58
226	35.328	-105.473	1,597	$367.41
227	35.655	-105.665	1,586	$369.96
228	35.983	-105.860	1,611	$364.21
229	36.311	-106.058	1,629	$360.19
230	36.640	-106.259	1,607	$365.12
231	36.968	-106.462	1,615	$363.31

Note: AC energy estimate based on 1-kW fixed-tilt PV system at latitude tilt and 0.8 derate factor

AC Energy Source: (NREL-b 2010)

Table 43. New Mexico Case Study Solar PV Premium Calculation

Description	Cost
Average Price of Fixed-Axis Solar PV in New Mexico [1]	$362.19
Average Price of Single-Axis Tracking PV in New Mexico [1]	$302.93
Blended Rate for New Mexico PV	$332.56
Average Price of Wind Energy in New Mexico	$81.40
PV Premium in New Mexico (2010$/MWh) [1]	**$251.16**

Note: [1] Based on results from Investigation 2 in this study

Table 44. New Mexico Case Study Residential Rate Impacts Detailed Calculations

Year	Solar Carve-Out (%)	IOU Annual Electric Sales (MWh)	Solar Generation Required to Meet Carve-Out (MWh)	RPS Net Annual Solar Generation (MWh)	Annual Cost to Meet RPS Generation (2010$)	IOU Annual Residential Customers (Qty)	Annual Residential Rate Impact per Customer (2010$)	Annual Residential Rate Impact per Customer (2010$/kWh)	Annual Residential Rate Impact per Customer (2010¢/kWh)	Projected Retail Residential Electric Rate (2010¢/kWh)	Average Annual Customer Bill (2010$)	Rate Impact (%)
Formula	*A*	*B*	*C* *= A * B*	*D* *= C₂ - C₁*	*E* *= D * Solar Premium*	*F*	*G* *= E / F*	*H* *= G / Usage*	*I* *= H * 100*	*J*	*K* *= J / 100 * Usage*	*L* *= G / K*
Note(s)	[1]	[2] [3]		[4]	[5]	[6] [7]		[8]		[9] [10]	[11]	
2008		13,300,411				530,361				$ 10.01	$ 862	
2009		13,768,082				550,006				$ 10.26	$ 883	
2010		14,252,197				570,379				$ 10.51	$ 905	
2011	2.0%	14,753,335	295,067	295,067	$ 74,109,342	591,507	$ 125.29	$ 0.01455	$ 1.45510	$ 10.77	$ 927	13.51%
2012	2.0%	15,272,094	305,442	10,375	$ 2,605,843	613,417	$ 4.25	$ 0.00049	$ 0.04934	$ 11.03	$ 950	0.45%
2013	2.0%	15,809,093	316,182	10,740	$ 2,697,470	636,139	$ 4.24	$ 0.00049	$ 0.04925	$ 11.31	$ 974	0.44%
2014	2.0%	16,364,975	327,299	11,118	$ 2,792,319	659,702	$ 4.23	$ 0.00049	$ 0.04916	$ 11.59	$ 998	0.42%
2015	3.0%	16,940,402	508,212	180,913	$ 45,438,241	684,138	$ 66.42	$ 0.00771	$ 0.77136	$ 11.87	$ 1,022	6.50%
2016	3.0%	17,536,063	526,082	17,870	$ 4,488,208	709,480	$ 6.33	$ 0.00073	$ 0.07347	$ 12.16	$ 1,047	0.60%
2017	3.0%	18,152,668	544,580	18,498	$ 4,646,023	735,760	$ 6.31	$ 0.00073	$ 0.07334	$ 12.47	$ 1,073	0.59%
2018	3.0%	18,790,955	563,729	19,149	$ 4,809,388	763,013	$ 6.30	$ 0.00073	$ 0.07320	$ 12.77	$ 1,100	0.57%
2019	3.0%	19,451,685	583,551	19,822	$ 4,978,496	791,276	$ 6.29	$ 0.00073	$ 0.07307	$ 13.09	$ 1,127	0.56%
2020	4.0%	20,135,648	805,426	221,875	$ 55,726,511	820,586	$ 67.91	$ 0.00789	$ 0.78871	$ 13.41	$ 1,155	5.88%
Total				**805,426**	**$ 202,291,841**	**7,005,019**						**2.95%**

Notes:

[1] Based on 20.0% of annual RPS total for investor-owned utilities

[2] 2008 annual electric sales based on actual totals from El Paso Electric, Public Service Co of NM, and Southwestern PSC.

[3] Annual electric sales escalated based on historical (2001-2008) electric sales data from state IOUs, or approximately 3.52%.

[4] Represents annual increase in solar generation to remain in compliance with RPS. Assumes all generation built in first year (2011) and incremental generation built thereafter to remain compliant.

[5] Represents total cost to meet RPS generation requirements in column D. Solar premium of $169.76 based upon results of Investigation 2 in this study and as detailed in previous table.

[6] 2008 annual residential electric customers based on actual totals from El Paso Electric, Public Service Co of NM, and Southwestern PSC.

[7] Annual retail electric customers escalated based on historical (2001-2008) data from state IOUs, or approximately 3.70%.

[8] Represents estimated annual rate impact on residential customers. Annual usage of 8,610 kWh/person in 2008 based upon historic data (2001-2008) from New Mexico IOUs.

[9] 2008 retail electric rate based on actual totals from El Paso Electric, Public Service Co of NM, and Southwestern PSC.

[10] Annual retail electric rates escalated based on historical (2001-2008) data from state IOUs, or approximately 2.47%.

[11] Represents average annual residential customer electric bill. Annual usage of 8,610 kWh/person based upon historic data (2001-2008) from New Mexico IOUs.

Table 45. New Mexico Case Study Life Cycle Analysis Detailed Calculations

Assumptions	**Row**	***Formula***	**Notes**	**Solar**	**Wind**	**Differential**
Carbon Footprint (grams CO_2e/kWh)	*A*		[1] [2]	52.00	4.64	47.36
Meeting the RPS in Missouri				**Solar**	**Wind**	**Differential**
Total Generation to Meet Ultimate RPS in 2021 (MWh)	*B*		[3]	805,426	805,426	
Total Generation to Meet Ultimate RPS in 2021 (kWh)	*C*	***= B * 1000***		805,425,920	805,425,920	
Carbon Emissions from Meeting RPS				**Solar**	**Wind**	**Differential**
Lifetime Carbon Emissions from Meeting RPS (grams CO_2e)	*D*	***= A * C***	[4]	41,882,147,860	3,737,176,271	38,144,971,589
Lifetime Carbon Emissions from Meeting RPS (pounds CO_2e)	*E*	***= D * 0.0022***		92,334,331	8,239,063	84,095,267
Lifetime Carbon Emissions from Meeting RPS (tons CO_2e)	*F*	***= E / 2000***		46,167	4,120	42,048
Carbon Emissions from Meeting RPS - Comparison to Coal				**Solar**	**Wind**	**Differential**
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (tons)	*G*	***= (F * 1MM) / (206 x 8400)***	[5]	26,680	2,381	24,299
Equivalent Qty of Coal Burned to LC Emissions Meeting RPS (ft^3)	*H*	***= (G * 2000) / 1000***	[6]			48,599
Months of Equivalent Coal Plant Operations	*I*	***= (G / 329783) * 12***	[7]			0.9
Carbon Emissions from Meeting RPS - Comparison to Gasoline				**Solar**	**Wind**	**Differential**
Equivalent Qty of Gasoline Burned to LC Emissions Meeting RPS (Gallons)	*J*	***= E / 19.4***	[8] [9]	4,759,502	424,694	4,334,808
Additional Cars on Road Based on Equivalent Emissions	*K*	***= J / 450***	[10] [11]	10,577	944	9,633
Carbon Emissions from Meeting RPS - Comparison to Deforestation				**Solar**	**Wind**	**Differential**
Equivalent Deforestation Rate to Meeting RPS (Acres)	*L*	***= F / (1 * (2204 / 2000))***	[12] [13]			38,156

Notes:

[1] Source: National Resource Council. *Electricity from Renewable Resources: Status, Prospects, and Impediments.* Washington D.C.: National Academies Press, 2010.

[2] Solar value (52) represents multi-crystalline silicon PV. Wind value (4.64) adapted from study performed by Vestas.

[3] Based on results from Investigation 3 of this study.

[4] Represents equivalent carbon dioxide emissions from satisfying solar carve-out objectives in state RPS.

[5] Represents equivalent tons of coal from using solar instead of wind to satisfy solar carve-out objectives in state RPS. Based on 206 lb/MMBtu CO_2 emissions rate and 8400 Btu/lb heat content.

[6] Represents total volume of equivalent tons of coal in row G. Based on assumption of 1,000 lb/ft^3 for density of coal.

[7] Represents how many months a 50-MW coal plant with an 8,600 Btu/kWh (HHV) heat rate and 85% net annual capacity factor (which would burn 329,783 TPY) would operate to release equivalent emissions.

[8] Represents gallons of gasoline that could be burned and would release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[9] Assumes 19.4 pounds/gallons of CO2 in gasoline. Source: Environmental Protection Agency (http://www.epa.gov/OMS/climate/420f05004.htm)

[10] Represents the number of additional cars that would be on road and release equivalent carbon dioxide emissions to satisfying state solar carve-out objectives in RPS.

[11] Assumes annual per capita gasoline usage of 450 gallons. Source: Perry Management, Inc. (http://perrymanagement.com/092605_cheap_gas.html)

[12] Represents the equivalent deforestation of land (in acres) from satisfying solar carve-out requirements in state RPS>

[13] Assumes a typical acre of forested land can sequester one metric tonne of carbon dioxide annually. Source: Environmental Protection Agency (http://www.epa.gov/sequestration/faq.html).